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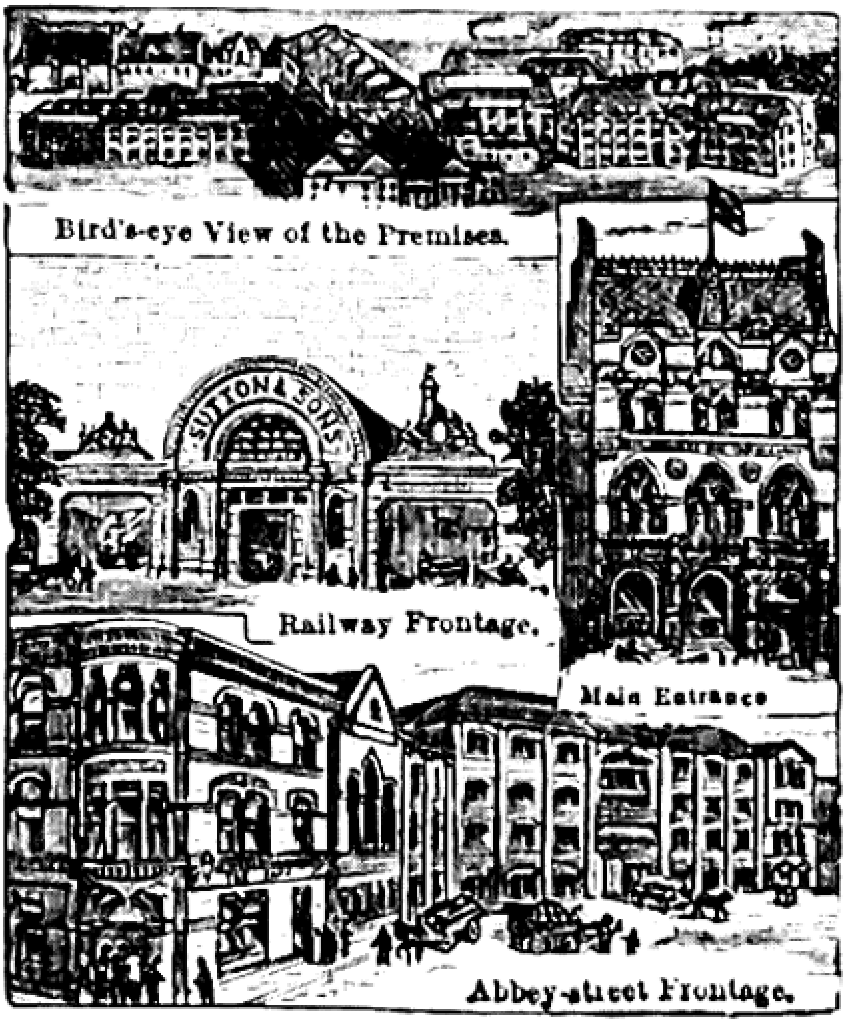

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THE
DISEASES OF CROPS
AND
THEIR REMEDIES:

A HANDBOOK
OF ECONOMIC BIOLOGY FOR FARMERS AND STUDENTS.

BY

A. B. GRIFFITHS, PH.D., F.R.S.E., F.C.S.,

Late Principal of and Lecturer on Chemistry and Biology, the School of
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School; Formerly Director of the Chemical Laboratories,
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"A Treatise on Manures," "Manures and their
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PREFACE.

As economic biology and pathology are subjects worthy of the deepest study on the part of farmers, market-gardeners, and others interested in the cultivation of crops,—my aim has been to make this little volume a useful companion to those who are interested in the diseases of crops caused by the attacks of parasitic insects and fungi.

The annual loss from the ravages of insects and fungi upon growing crops is beyond calculation; but it may be estimated that on the average at least "one-sixth" of the entire yield of farm-crops, hop-gardens, etc., is sacrificed through the ravages of insect and fungoïd pests.

"As actual instances of the enormous losses which farmers sustain through the ravages of *insects*, it may be mentioned that Miss Ormerod estimated, for the season of 1881 alone, the financial loss represented by the cost of seed and the expenses of sowing and re-sowing the turnip crop destroyed by the 'turnip-fly' in twenty-two English and eleven Scotch counties, amounted to over half a million pounds sterling." In Mr. Whitehead's *Official Reports* for 1886 and 1887 it is stated, "that the 'diamond-back turnip moth' is the cause of losses estimated at from £4 to £6 per acre; that the 'dart moth' occasioned to a market-gardener in Essex losses to the extent of more than £100; that through the 'mangel-wurzel fly' farmers in Derbyshire and Hampshire had both lost over £100 in one season on this crop alone; and that the losses to hop-growers due to the hop aphis have been incalculable. In the last serious blight in 1882, the whole produce of the hop lands in England—65,619 acres—did not exceed 114,832 cwts., or a yield of 1¾ cwt. per acre." For comparison, it may be stated that on an average the English hop lands yield about 7 cwts. per acre.

As an instance of the losses caused by *fungoïd* pests, we may allude to the much-dreaded *Peronospora infestans*. There is no doubt that "the potato disease in a bad year affects the whole community; but it falls with crushing force upon the large growers, for the potato is always an expensive crop. The amount paid away in 1880 in consequence of the failure of the preceding year, was £2,847,027. Yet in 1885, after a smaller area by 18,987 acres, £727,806 sufficed to make good our requirements. This enormous difference of £2,119,221 roughly indicates the loss sustained by home potato-growers in 1879; and that season had been preceded by several other scarcely less calamitous years."

Therefore nothing more need be said of the practical utility of the subject discussed in the following pages.

The main object of this volume is to detail, in a concise form, the life-histories of the principal insect and vegetable foes of the farm, and to give an account of the means for destroying them or preventing their attacks.

The *microscope* being of such practical utility for the proper study of parasitic fungi and insects (and especially the former), a short chapter has been added concerning its use as a means of examining and studying the various parasitic fungi and insects detailed in the present volume. In my opinion, the best objectives are those made by Zeiss of Jena; in fact for clearness of definition they are unsurpassed by any other maker.

No author could well approach the subject of economic biology without consulting the works of Berkeley, Cooke, Curtis, De Bary, Lindeman, Ormerod, Plowright, Riley, Smith, Taschenberg, Westwood, Whitehead, Woronin, and others: to these, I take this opportunity of acknowledging many obligations.

My best thanks are given to Dr. Carl Zeiss, Dr. K. Lindeman (Professor in the Academy of Agriculture, Moscow), Messrs. S. T. Griffiths, G. F. Strawson, C. Whitehead, F.L.S., J. E. Mason, L. O. Howard (Department of Agriculture, U.S.A.), B. P. Galloway, and the Hon. N. J. Colman (formerly Commissioner of Agriculture, U.S.A.), for valuable information.

I may add, that I have received the constant assistance of my wife (*née* Frances E. Wright), whose knowledge of botany has been no mean help to me in many ways.

In conclusion, I hope that the present volume may prove useful in helping farmers and others to increase the produce of the soil by preventing or curing those diseases caused by the attacks of numberless farm pests.

A. B. GRIFFITHS.

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THE DISEASES OF CROPS.

CHAPTER I.

INTRODUCTION.

THE object of the present book is to give, in a concise form, an account of the "doings" of the more important members of the animal and vegetable kingdoms which are injurious to farm crops.

As the scope of the volume is limited, it is not proposed to include the life-histories of the organisms which prey upon *fruit* and *forest* trees, as these do not concern the majority of British farmers.

After describing the life-history of each "insect" and "fungus" and their modes of attack, various methods will be given for the prevention and cure (as far as possible) of each disease.

By *prevention* is meant, those methods of cultivation, etc., which will procure the production of strong, vigorous and healthy plants, capable of resisting the attacks of that "unseen mist of organic forms."

By *cure* is meant a description of the various re-agents, etc., which are capable of destroying farm pests without causing injury to the crops themselves.

The vine is liable to be attacked by some 350 parasitic fungi in addition to the *Phylloxera* and other animal pests! Happily our English farm crops have not such an array of deadly foes as the vine. The wheat has its "mildew," its "smut," its "canker," besides such animal foes as the corn-weevil, the corn fly, the wire-worm, and the Hessian fly. The potato has its *Peronospora*, its Colorado beetle, etc.

The mildews and other fungi which infest farm crops are all "built" more or less upon the same structural plan. They take their origin in *spores* which are found in the atmosphere, soils or water. The spores give rise to *hyphæ* (filaments), which live principally upon the albuminous substances found within the living cells of various farm crops. Each hypha (in the majority of cases) is composed of a variable number of microscopic cells placed end to end, and each cell is composed of an external wall or covering of a peculiar kind of *cellulose*, and contains a living granular substance called protoplasm ("the basis of life"). The cellulose of parasitic and saprophytic fungi is of a different nature to that found in the higher plants.

The hyphæ (produced from spores) branch and become closely interwoven and twisted in all directions. This "mat-like" mass of hyphæ is called a *mycelium*,[1] and gives rise to elongated cells springing vertically in the air, bearing, at their free ends, spores.

As fungi, unlike the higher plants, contain no *chlorophyll* (green matter), they are incapable of living upon such inorganic or mineral substances, as atmospheric carbonic acid gas, water, ammonia and various soluble salts. Because they are incapable of "manufacturing" albumin, etc., they live parasitically on living or dead organisms, thereby obtaining the required albuminous substance requisite to sustain life.

---

[1] **There is no connection between cells, which are in apposition in two separate hyphæ. This is one of the distinctions between fungoïd "tissues" and those of higher plants.**

Fungi living on dead or decaying organic matter are termed *saprophytes;* others infesting living plants, causing more or less serious disease in the host, are termed *parasites.*

According to Dr. Sieber (*Journal für Praktische Chemie* [2], 23, p. 412) certain common mildews have the following compositions:—

	I.	II.
Albumin	29·88	28·95
Cellulose	39·66	55·77
Ash	4·89	0·73
Substances soluble in ether	18·70	11·19
Substances soluble in alcohol	6·87	3·36
	100·00	100·00

The analyses show that mildews contain a considerable percentage of albumin, derived in the first instance from the host-plant upon which the parasites live. The host-plant thereby becomes diseased, and its vitality is greatly impaired. The vitality of the spores of most fungi is very considerable; and the spores are capable of being dried up in the dust of the atmosphere for months, and it may be years, without losing their vitality.

So far, we have spoken in a general way of the structure, etc., of the vegetable foes which are injurious to farm crops. We now offer a few remarks concerning those members of the animal kingdom which are undoubtedly the foes of the farm.

The majority of the animal foes which cause disease in crops belong to the great class of *Insecta ;* a few are members of the *Vermes* (worms) and the *Myriapoda* (millipedes).

"INSECTS in their most complete character pass through four stages or phases of existence—the egg, the larva (maggot or caterpillar) stage, the chrysalis, and the perfect state. In none of these, except the larval or caterpillar stage, does the insect increase in size. . . . After insects have come out of the chrysalis stage they never grow—all the growth is done in the earlier stage when they are caterpillars. If we sometimes meet with two insects of the same species but of different size, the difference is due to the supply of food which the caterpillar had during its growth, and is only a parallel case to an ill-nourished child growing up into a stunted man. Some insects, as the *Aptera* (wingless insects), pass only through three stages: the egg, the 'younger stage' and the perfect form; and some of the intermediate orders also attain perfection without passing through more than two.

"The egg is usually deposited externally, but in some few cases it is hatched in the body of the parent; in some others it is deposited at one period of the year, and the progeny brought forth alive at another period. . . . In the *larval* stage, the insect casts its skin or moults several times, after each casting attaining a sudden and rapid increase of size. The larva does not always take the form of a caterpillar or maggot. In some orders (the *Aptera*, *Hemiptera* [bugs] and *Orthoptera* [cockroach, dragon-fly, thrips]) it assumes a good deal of the appearance of the perfect insect. In this imperfect metamorphosis it changes its skin as the caterpillars do, and it does not assume a different form for the chrysalis stage.

"In the other orders (*Diptera* [two-winged flies], *Hymenoptera* [bees, wasps, ants], *Neuroptera* [caddis-fly], *Lepidoptera* [butterflies and moths], *Coleoptera* [beetles]) the larva, on its last change of skin, assumes a new form known as the chrysalis or pupa, in which stage it lies dormant and nearly motionless, shut up like a body in the shroud, until the last change takes place, when it comes out as the perfect insect. This chrysalis in some cases merely consists of the hardened skin of the animal itself, and is left unprotected and bare in the open air, or in the earth or other place of concealment; but in other cases a cocoon or case is made by the larva for it, previous to and in anticipation of the change, in some spun like the cocoon of the silk-worm, in others composed of fragments of earth or bits of wood, etc., glued together" (Murray).

Insects in their *perfect* state, are distinguished from other articulate animals by the possession of six legs and two antennæ ("feelers"), and by the division of the body into three distinct regions—the head, thorax, and abdomen, of which the second bears the organs of motion. The *mouth* of the insects exhibits remarkable modifications. In some it is used exclusively for biting, in others for suction, whilst in others again it is constructed for the performance of both these actions. The *eyes* of insects are compound and sessile; sometimes simple eyes are added to them.

Insects are all unisexual animals. Hermaphroditism, where it occurs, is quite exceptional in its nature, and very rarely gives rise to fertile individuals. The females are usually larger and broader than the males, but in most cases the structure of the apex of the abdomen at once indicates the sex; besides the antennæ and tarsi (feet) often present well-marked differences in the two sexes. The reproduction of insects is essentially oviparous (producing eggs), some are ovo-viviparous (*i.e.*, the eggs are hatched and the young developed to a greater or less extent *within* the body of the parent), and a few (*Aphides*) are viviparous (producing living young) at certain periods. The ravages of insects, which sometimes occasion such serious panics, are explained by their enormous fecundity. Sir Richard Owen, K.C.B., F.R.S., estimated that a single *Aphis* in the tenth generation produced no less than 1,000,000,000,000,000,000 (a quintillion) young (Owen's "Invertebrata," p. 44).

We propose to arrange the subject matter of this book under the following headings:—

(α) The Diseases of Leguminous crops.
(β) The Diseases of Root crops.
(γ) The Diseases of Gramineous crops.
(δ) The Diseases of Miscellaneous crops.

In each case the diseases produced by the members of the animal kingdom will be described first, and the fungoïd diseases afterwards.

The subject of *nomenclature* throughout this book is not thoroughly "orthodox," and may possibly awaken some controversy. As every scientist has his own views on this subject, the author may be permitted to have his. Concerning the nomenclature used it will be noticed that no *describers' names* are appended to the species described. Thus *Anthomyia Brassicæ*, Bouché; *Tipula oleracea*, Linnæus; *Peronospora Viciæ*, Berkeley; *Peronospora trifoliorum*, De Bary, etc., become: *Anthomyia Brassicæ; Tipula oleracea; Peronospora Viciæ; Peronospora trifoliorum*, etc.

The late Mr. Darwin was averse to the "orthodox" system of nomenclature, as the following quotations from

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"The Life and Letters of Charles Darwin" (vol. i. pp. 365–372) will show :—

(*a*) "Why should naturalists append their own names to new species, when mineralogists and chemists do not do so to new substances?"

(*β*) "I have come to a fixed opinion that the plan of the first describer's name being appended for perpetuity to a species has been the greatest curse to natural history."

(*γ*) "I mean to adopt my notion, as never putting 'mihi' or 'Darwin' after my own species."

Then again, as this is not a *systematic* work on the subject of which it treats, no harm is done by "dropping" the describers' names generally attached to the organisms alluded to. It will be our interest to learn more about the things themselves than to ascertain the names—useful or not—which the nomenclators have affixed to them.

"J'ai toujours cru qui on pourrait être un très grande botaniste sans connaître un seul plante par son nom," wrote the celebrated Rousseau in his "Dictionnaire de Botanique." And if one can be a "very great botanist without knowing the name of a single plant," so might one be an entomologist, or a zoologist, if not great, at least intelligent, without troubling oneself about any system of "*naming*" used by experts.

To conclude the chapter in the words of Mr. W. G. Smith, F.L.S.: "All agriculturists should, if possible, arouse themselves and learn something of the nature and surroundings of plant disease. Till this knowledge is acquired, and till agriculturists become alive to the possibility of saving their crops from disease, little progress can be hoped for. We do not say that it is necessary for every farmer to be a complete master of the anatomy and physiology of all the plants he grows, or to be perfectly familiar with the life-history of every assailing parasitic fungus or destructive animal, any more than a householder should know all about the exact nature of typhus, or diphtheria, or bacteria, bacilli, and disease germs; but as every householder at length begins to know, amongst other facts, that an open drain is likely to prove fatal to life, so every farmer should know, amongst other things, that imperfectly drained fields and rotting vegetable refuse mean disease and destruction to his crops."

CHAPTER II.

THE DISEASES OF LEGUMINOUS CROPS.

(1) THE PARASITES OF THE BEAN (*Vicia faba*).

The Bean Aphis (*Aphis fabæ*, "black-fly," "colliers," etc.) is a member of a tribe almost entirely composed of the *Aphides*, or plant-lice. The *Aphides* are all small animals furnished with six legs and a pair of antennæ, and usually with a pair of short tubes close to the extremity of the abdomen, from which a clear sweet secretion exudes. They all live upon plants, the juices of which they suck, and when they occur in great numbers cause serious damage to the crops they attack.

Both sexes are sometimes winged and sometimes wingless. "But the most singular portion of the history of these insects is their very curious manner of propagation. In the autumn, male and female insects are found, furnished with perfect generative organs; these copulate, when the females lay eggs, which are hatched the following spring. But, instead of producing individuals of both sexes, these eggs give birth only to female insects, which produce living young without any congress with the male; the brood thus brought forth again produces living young in the same manner, and this goes on throughout the whole summer, without the appearance of a single male insect. In the autumn again, male and female individuals are produced, and the latter lay eggs which are to continue the species until the following summer." From what has been said in the previous chapter concerning the enormous fecundity of these insects, the farmer can hardly wonder that his crops are completely destroyed, from time to time, by these pests. Provided with a warm moist summer and a plentiful supply of food, the various species of *Aphis* multiply prodigiously.[1]

The Bean Aphis, like most insects, passes through three stages of its life-history (*i.e.*, larva, pupa, and perfect state); but as far as their shape or general *contour* is concerned there is little to distinguish one stage from another. During the larval and pupal stages they have no wings, but possess six legs. In these stages the colour is from grey to black; becoming blacker as age increases.

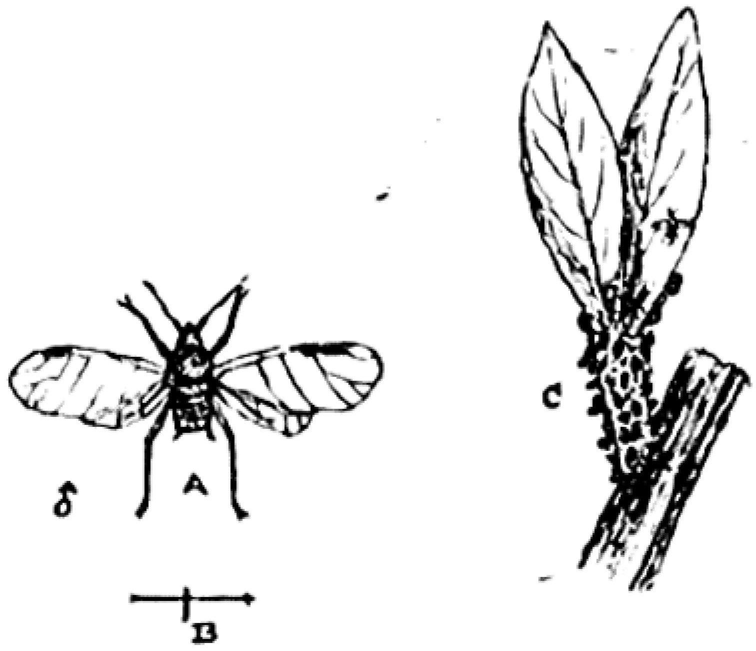

Fig. 1.—Bean Aphis (*Aphis fabæ*).

A. Male Aphis (enlarged).
B. Its natural size.
C. A young bean stem covered with Aphides.

The male insect (Fig. 1 A) is black, generally winged, and measures about one-third of an inch across the extended wings. There are three kinds of females. (1) A wingless black one. When examined by a magnifying lens, the head, thorax, and abdomen appear to be fused into one mass. This wingless female is viviparous (*i.e.*, produces living young). (2) A winged viviparous female, which has a black body, and wings partly yellow and partly green with brown veins. (3) A wingless female which is oviparous (*i.e.*, produces eggs). The oviparous female only appears in the autumn; and the eggs produced by her are hatched in the following spring. The wingless females produced from these eggs then settle down upon the young "shoots" of the bean plants, and may cover, in a very short time, a whole crop of beans with their progeny. These insects puncture the bean plants by means of their suckers and extract the juices. This causes a reduced state of vitality, which terminates (if the attack is not stopped) in the failure of the crop.

---

[1] For further details concerning the reproduction of *Aphis*, see the papers of Balbiani (*Annales des Sciences Naturelles*, 1869–1872) and of Huxley (*Linnean Society's Transactions*, 1857).

Prevention.—(1) To prevent the attacks of the bean aphis, the farmer should carefully remove thistles, curled dock, gorse, and other wild plants on which the insect is found. (2) To produce a healthy and vigorous growth by the judicious use of manures. A good system of cultivation is always a means of lessening the attacks of this insect.

Cure.—(1) As soon as the "plague" makes its appearance, cut off all the infested "tops" and burn them. (2) Where the crops are on a small scale, soot or soap-suds are means of getting rid of the bean aphis. (3) Manuring the land with a top-dressing of iron sulphate ($\frac{1}{2}$ cwt. per acre) has a tendency to produce a luxuriant growth; and after this treatment the plants are rarely attacked by this injurious insect.

The Humble Bees (*Bombus lucorum*, *Bombus terrestris*), whose nests are generally constructed of moss, containing a few waxen cells, at times injure bean crops by piercing the calyx of the flower, so as to extract the nectar inside. This often causes the fall of the flower or seedless pod.

Prevention.—The only means is to destroy their nests.

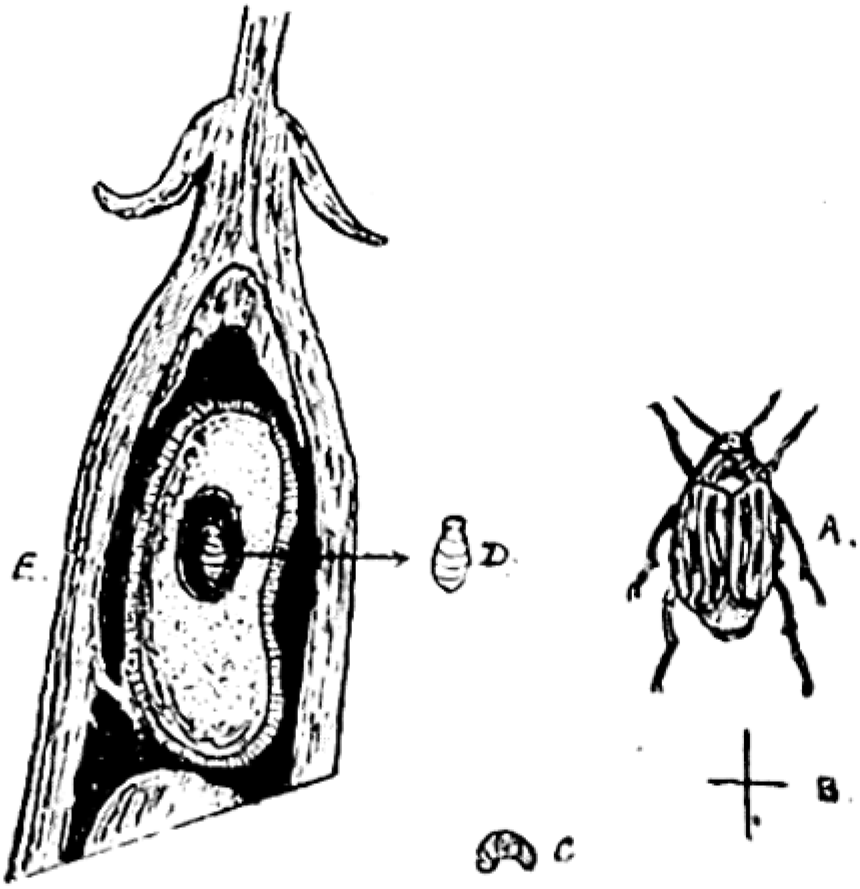

Fig. 2.—Bean Beetle (*Bruchus granarius*).

A. The beetle (enlarged).
B. Its natural size.
C. Larva (natural size).
D. Pupa (natural size).
E. Injured bean.

The Bean Beetle (*Bruchus granarius*) is a member of a vast group of beetles, which embraces several thousand species. The group is popularly known under the name of *weevils.* "Many of these creatures are extremely injurious to vegetables, both while growing and when stored up in barns and granaries."

The Bean Beetle (Fig. 2 A) attacks bean, pea, and other crops. It lays its eggs, in the spring, in the soft young pods. After the hatching of the eggs, the larvæ (maggots) feed upon the fleshy cotyledons of the seed, but often leave the germ and husk intact. Each seed contains only one maggot, which ultimately turns to the pupal state within the bean or pea (Fig. 2 E); where it (the pupa) hibernates until the spring, when it becomes a perfect insect. The beetle then escapes from its enclosure by gnawing its way out. The body of the bean beetle is about one-sixth of an inch long, of a black hue with various white spots. The front legs are of a reddish colour.

Cattle and other farm animals fed upon beans infested with these insects are often seriously injured thereby.

Prevention.—(1) Infested seeds should not be sown. They are distinguished from sound ones by having roundish marks (about the size of the larva, Fig. 2 C) more or less transparent. Maggot-eaten seed always produces sickly plants, easily liable to be attacked by parasitic fungi as well as animal foes. (2) As bean beetles are frequently found largely in foreign seeds, such seed should be carefully examined during the winter months.

Cure.—(1) "It is difficult to apply any remedy in the field suitable to such a small insect; but the use of *spent hops as a manure*, which is found serviceable in other cases of insect-attack, might be of use here." (2) Mr. W. L. Wilson states that he found every insect dead after treatment with a mixture of paraffin oil and water; ten parts of water to one of paraffin oil. An easy method of application would be the setting of two empty "paraffin barrels" on a stand, both fitted with a good large wooden tap, which can be had for about 4*d.*, whilst the empty "paraffin barrels" are easily procured. The first barrel should have one gallon of paraffin oil and ten of water poured into it, and the seed (peas or beans) should be put in to soak an hour. The liquor should then be run off, put into the second barrel, and this should also be filled up with seeds; and so on, using the barrels alternately until all the seeds have been soaked. The seeds thus pass through the oil twice; once when they are poured in, and again when the liquor is drawn off, because, as the oil floats on the water, it comes off last; and the beetles appear to be all killed by it without any harm being done to the vegetable germ.

The Bean Weevils (*Sitona crinita*, *Sitona lineata*) are often injurious to other leguminous crops besides beans. These beetles devour the *leaves* of the infested crops. For a description of their life-histories, etc., see later in this chapter, under the heading of "Pea Weevils."

Julus pulchellus is the commonest of the "snake millipedes," and is one of the so-called "false wireworms." The true wireworm has only six legs, whereas *Julus* has many. According to the late Mr. Curtis, *Julus pulchellus* feeds upon the roots of beans, cabbages, and also upon the roots of young wheat.

Prevention and Cure.—See the article under the heading: "The Diseases of Corn Crops."

The Bean-Root Fungus (*Ustilago fabæ*). A considerable amount of work has been performed in investigating the nature of the nodular outgrowths upon the roots of various plants. One of the earliest observations in this direction was by Naegeli in 1842, who found that the swellings upon the roots of *Iris* were caused by a parasitic fungus. The peculiar nodules upon the roots of various members of the *Leguminosæ* have been examined by Malpighi, De Candolle, Woronin, Kny, Treviranus, Ward, the author, and others. Dr. Tschirch considered that these swellings were the storehouses for nitrogenous compounds—these compounds being subsequently used up in the ripening of the seed. But it has been shown by subsequent research that Tschirch's idea is erroneous, and that these root-nodules are pathological or disease structures, caused by a microscopic fungus whose spores are, at times, found in cultivated soils.

During the seasons of 1886 and 1887, field and garden beans were attacked, more or less, by a fungus which caused nodular out-growths upon the roots, and thereby caused great injury to the crop (Fig. 3).

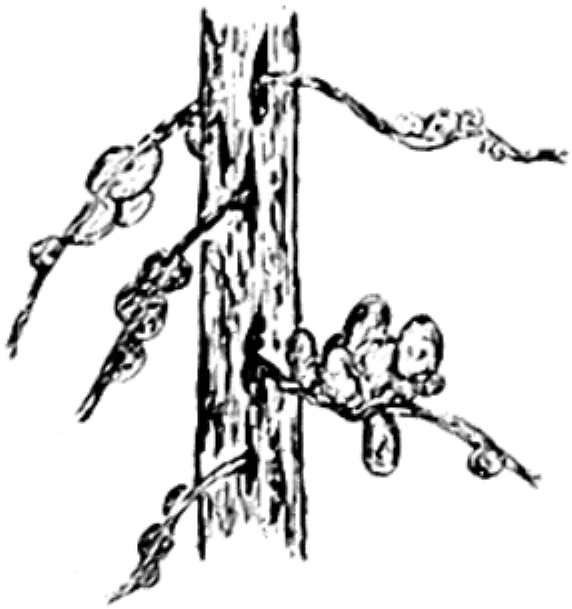

Fig. 3.—Roots of Broad Beans, (*Vicia faba*) infested with a fungus causing nodular out-growths.

In the neighbourhood of Etton, near Peterborough, the crops of winter beans were, during 1887, a complete failure. Mr. G. W. Edgson (a well-known farmer) of Etton sent the author a number of these bean plants for inspection. They were about seven inches long. Mr. Edgson wrote as follows: "The roots of the winter beans, you will find, are covered with small boils, which appear to be living upon the plant, and have kept the bean plants in the stage you now see them. For the last few months the crop in this district has been a failure. Not having seen anything like it before, I thought it would be interesting for you to see them." The author found that these "boils" were caused by the growth of a parasitic fungus within the root, etc., of the bean plant (*Chemical News*, vol. 56, p. 84; *Lincoln Gazette*, June 4th, 1887). A complete study of the life-history of the bean-root fungus has been made by Professor H. M. Ward, F.R.S. (*Philosophical Transactions of the Royal Society*, 1887).

Prevention.—Avoid sowing maggot-eaten seeds or seeds from infested crops. Such seeds cannot produce healthy plants.

Cure.—(1) The author found that iron sulphate completely destroyed the spores, hyphæ, and mycelia of this fungus (*Chemical News*, vol. 56, p. 84). The iron sulphate should be used as a top-dressing ($\frac{1}{2}$ cwt. to the acre), either mixed with sand or dry soil, or alone, when the young plants are just above ground. (2) After the seed-bed has been prepared, water it with a solution of iron sulphate (from $\frac{1}{2}$ to 1 lb. of iron sulphate per gallon of water). This will destroy any fungoid spores that may be in the soil.

"Bean Brand" (*Puccinia fabæ*) occurs about August or September. It produces no spots on the bean plant, but its sori (masses of spores) are surrounded by a ruptured epidermis. The spores are black.

The Bean Mildew (*Erysiphe Martii*). For a description of this parasitic fungus see later in this chapter, under the heading of "Pea Mildew." The Bean Mildew attacks beans, peas, and other plants.

(2) THE PARASITES OF CLOVERS.

The Clover Weevils. These small beetles devour the leaves of clover plants. They will be fully described under the heading of "Pea Weevils."

The Clover Eelworms (*Tylenchus devastatrix* and *Tylenchus Havensteinii*, Fig. 4) are one of the causes, if not the cause, of "clover sickness." They belong to a group of nematoids or "thread-worms," known as the *Anguillulidæ*. Drs. J. Kühn (*Biedermann's Centralblatt für Agricultur-Chemie*, 1882, p. 270), Havenstein, Taschenberg and others in Germany, as well as Mr. Whitehead and Miss Ormerod in this country, consider that "clover sickness" is due to the attacks of eelworms.

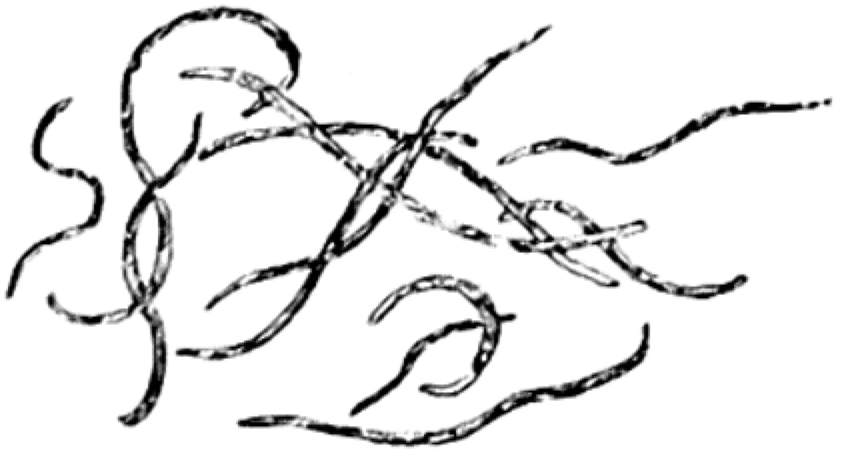

Fig. 4.—CLOVER "EELWORMS" (enlarged).
One of the causes of "clover sickness."

These eelworms of clover have rather elongated rounded bodies which taper towards each end: they are not divided into segments (like the true worms), and although they are devoid of limbs, they have considerable powers of locomotion. These nematoids are found on and in the leaves and stems, as well as in the roots of clovers. These organisms thrive only in the *living* portions of plants, where they extract the plant-juices by means of their suckers, thus causing a diseased condition of clover crops. The nematoids of clover are never actually parasitic, although they seriously injure these crops. It is only during the pairing season that they become parasitical, for then they require an abundant nitrogenous food in order to develop their sexual organs; and hence they are found in the sexual state only within the tissues of clover and other plants. During the winter the sexless worms appear to live or hibernate in moist earth (Kühn). The female multiplies with great rapidity so long as the store of food lasts. It appears that their power of fecundity is in direct proportion to the quantity of living organic nitrogen they are able to obtain. When the food is exhausted the last hatched young wander away and attack other plants, or assume the "dormant" condition until another season. The eggs are always laid within the host-plants. These give rise to larvæ which are "more blunt at the extremities than the mature eelworms."

The clover eelworms are possessed of very great tenacity of life. According to Dr. C. Devaine ("Recherches sur l'Anguillule du blé niellé") certain species of *Tylenchus* may be exposed to −4° F. "for several hours, without destroying their vitality. About 148° F., however, is the maximum of heat in which they can exist." Eelworms appear to be able to retain their vitality for several years; and Dr. Kühn (*Ueber die Wurmkrankheit des Roggens*) found that *Tylenchus devastatrix* retained its life for two years in a state of complete desiccation, and much longer in damp earth.

"With respect to infested clover plants . . . some of the eelworms would remain in the leaves and stems left in the plants after the first and second 'cuts' had been mown. These, together with any that may have escaped into the ground, are buried by the plough, and are brought up again by a future ploughing in course of time to the reviving influences of air and light. It is most probable that eelworms being in the stalks of clover made into hay are taken also into the fields in the nose-bags of cart-horses, and in the fodder supplied to folded sheep, as well as in the manure from animals fed in yards with this hay" (Whitehead).[1]

Prevention.—(1) Rotation of Crops. Lawes and Gilbert in their paper on "clover sickness" (*Journ. Roy. Agric. Soc.*, vol. xxi.) state, "that as far as our present knowledge goes, the only means of insuring a good crop of red clover is to allow some years to elapse before repeating the crop upon the same land"; and Mr. Whitehead states that "oats should also be avoided for some time, especially where deep ploughing cannot be resorted to." (2) Farmyard manure from horses, etc., fed upon clover and oats infested with these nematoids is "a very common means of spreading infestation." The manure derived from these crops should not be used for leguminous and cereal crops; but may be used for root crops. (3) The clover nematoids also infest the common daisy, crowfoot, shepherd's purse, and similar weeds. These should always be destroyed as far as possible. (4) "The plants upon clover leys where 'clover sickness' has prevailed, should be buried deeply, in order that they may not be dragged up again to the surface by the harrows catching in their long roots. This, of course, cannot be done upon some light chalk and other soils where the surface mould is shallow, but it should be carried out as far as possible."

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[1] For further information concerning the life-history, etc., of various nematoids, see Dr. Bastian's "Monograph" in *Transactions Linnean Society*, vol. xxv.; Schneider's *Monographie der Nematoden*, 1866; Claus' "Ueber einige in Humus lebende Anguillulinen" (*Zeitschrift für Wissenschaftliche Zoologie*, vol. xii.); and the paper by Dr. Ritzema Bos in the *Biologisches Centralblatt*, vol. vii., No. 9.

Cure.—(1) Before clover leys and oat stubbles are ploughed in, they should be treated with a liberal dressing of common salt or quicklime. By this means a large number of, if not all, the nematoids are killed. (2) Kühn, Oehmichen and others (*Biedermann's Centralblatt für Agricultur-Chemie*, 1882, p. 270) recommend strong manuring with kainit in cases of "clover sickness."

The "White Worms" of Clover. Professor A. Harker, F.L.S., in *Nature*, vol. 40 [1889], p. 11, writes that it is most probable that certain members of the *Oligochæta*,[1] and more particularly *Enchytræus Buchholzii*, attack the roots and stems of clovers, vegetable marrows, and other plants. This "white worm" is about 1½ inch long, and is supposed to injure the plants by "sucking the fine root-hairs." The "white worms" appear to like the more or less decayed roots of plants, rather than healthy ones; although the latter harbour a few specimens. Harker says there is "but little room for doubt that these small *Oligochætæ* are one cause of the decay of the clover of Rothamsted."

Prevention.—(1) A good system of draining the land will no doubt lessen the activity of these so-called "white worms." (2) Produce a healthy and vigorous growth by using pure seed and suitable manures.

The Clover Dodder (*Cuscuta trifolii*, Fig. 5) is a member of the natural order *Convolvulaceæ*, although it is a parasite. Clover dodder is incapable of elaborating albuminous and carbonaceous substances from such inorganic materials as: carbonic acid, water, ammonia (or rather nitrates) and certain salts, like the higher plants.

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[1] The earthworm belongs to this natural order.

The twining stem of dodder is of a yellowish colour, containing (in the spring and summer) clusters of pinkish, funnel-shaped flowers, and is provided with suckers (Fig. 5 B) which are used for extracting nourishment from the host upon which it lives. The seeds of dodder have a *rough* surface, and are smaller than those of the clover plant. The seeds of both clover and dodder are of a brown colour, but the former have a smooth surface.

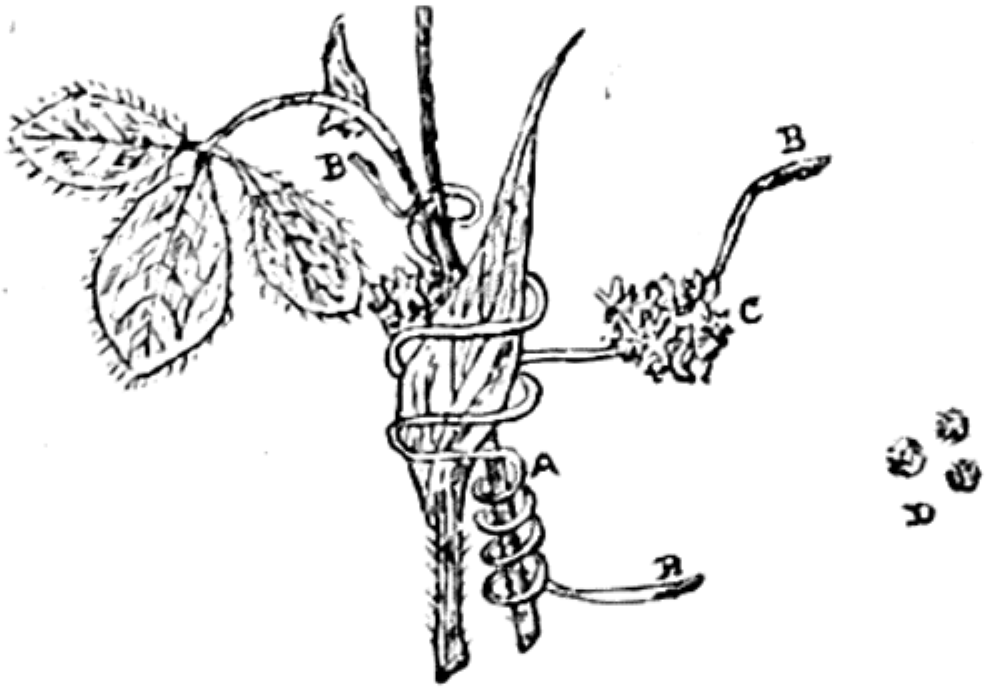

Fig. 5.—Clover Dodder (*Cuscuta trifolii*).

A. Dodder entwined round clover.
B. Suckers.
C. Clusters of dodder flowers.
D. Seeds of dodder, × 2.

When the dodder has settled upon the clover plants, it, at first, grows at about the same rate as the host; but after a time the increase of its branches and suckers far exceeds the growth of the clover.

The suckers pierce through the cellular tissues to the central pith of the clover stems; and there the parasite is nourished at the expense of the host. "The dodder completely drains out the elaborated juices of the clover, and kills it by exhaustion."

Dodder rarely produces seed in Great Britain, but its stems are often perennial. "In the early stage of its existence dodder is not a parasite, for after the germination of its seed, it grows like an ordinary plant, sending its roots down into the soil, from which it draws its nourishment. This state of existence, however, is short, for unless it meets with some congenial plant to which it can attach itself, and from which it can draw nourishment, it withers and dies."

Prevention.—(1) Dodder grows upon other plants besides clover: *viz.*—nettles, broom, furze, yellow bedstraw, sow-thistles, etc. These should be removed from all lands growing clover. (2) Continental clover seeds often contain those of dodder. The latter should be sifted away as far as possible.

Cure.—(1) "The Continental remedy is to dissolve iron sulphate in water, at the rate of 1 lb. to the gallon, and water the infected spots with the solution. This kills the dodder and leaves the clover uninjured." (2) "Carefully collect and burn all the patches of dodder after the crop has been removed, and then give the field a good clean fallow. All such operations as harrowing and raking do harm, for instead of extirpating the dodder, they only further the mischief, as it is well known that if the dodder is cut into a hundred pieces, each piece will go on growing and become a separate plant."

The Clover Mildew (*Peronospora trifoliorum*, Fig. 6) is a fungoid growth, and is one of the causes of "clover sickness." *P. trifoliorum* grows within the leaves of the clover plant, although it sends out aërial branches (conidiophores) through the stomata (openings) which are found largely on the under surface of the leaves (Fig. 6 *a*). The conidiophores bear oval spores (conidia, Fig. 6 *b*). These spores germinate when provided with moisture and a suitable medium, and ultimately give rise to conidiophores. The spores of the clover mildew, like those of every fungus, consist of living protoplasm surrounded by a cellulose covering. Near the end of the season, true sexual organs (analogous to the carpels and stamens of the higher plants) are produced from certain hyphæ *within* the leaves of the host-plant (Fig. 6 C, *d*).

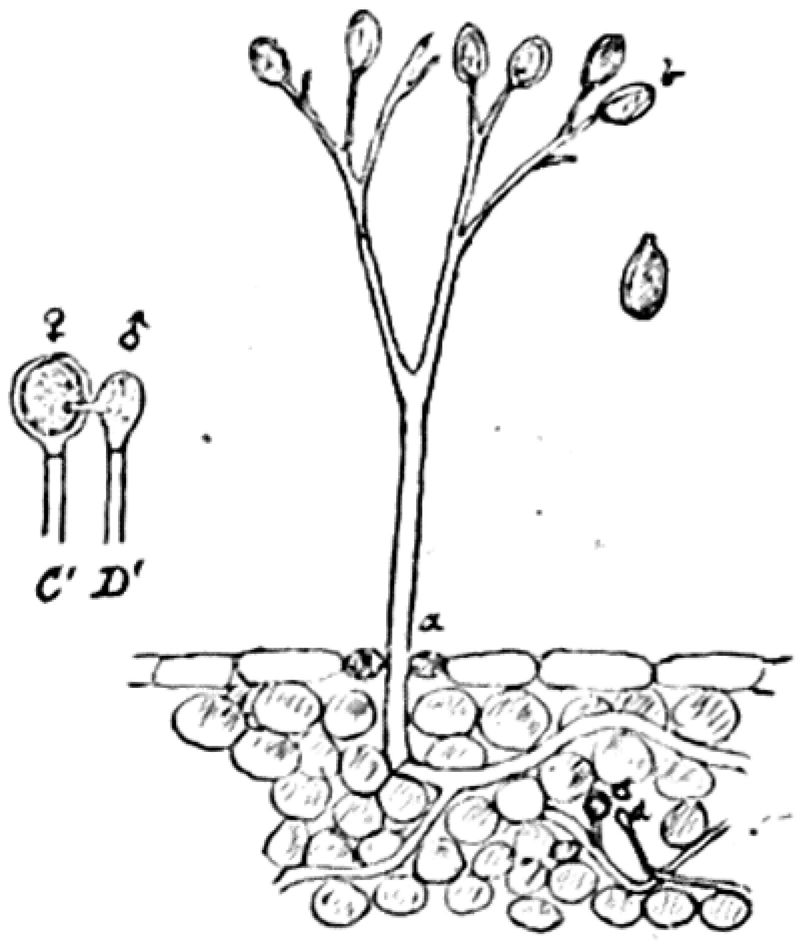

Fig. 6.—**Clover Mildew** (*Peronospora trifoliorum*).
One of the causes of "clover sickness," × about 200.

The largest of these organs (Fig. 6 C′) is the oögonium, or egg-cell; and the smallest (D′) is the antheridium, or male cell. The former contains an oösphere. After the antheridium and oögonium have been in contact, and their contents thoroughly commingled, the antheridium dies away; but the oögonium increases in size and becomes an oöspore or resting-spore. The oöspores fall to the ground in the autumn, and hibernate until the summer, when they germinate on clover leaves, giving rise to internal hyphæ and mycelia, which in due time bear conidia.

The growth of this mildew injures the clover plant in several ways: (1) By simple contact it causes putrefactive changes to occur within the tissues of its host. (2) It clogs up the organs of assimilation and transpiration (the stomata), and thereby greatly interferes with these physiological functions, which are necessary for a healthy and vigorous growth. (3) This mildew produces brownish spots on clover leaves.

Prevention.—(1) Avoid thick planting, for it favours the attacks of *P. trifoliorum.* (2) Burn all clover refuse, as it harbours the resting-spores of this fungus. (3) The land should be well drained, as *P. trifoliorum* is "fond" of moisture.

Peronospora exigua was discovered by Mr. W. G. Smith, F.L.S., and is very similar in its life-history to the clover mildew. It is much smaller than *Peronospora trifoliorum*, and causes putrefactive changes within the cells of the leaves of clover. This fungus, whose conidia are almost round, produces oöspores like the clover mildew.

Besides the two species of *Peronospora* described, several other fungoid growths are, or have been, put down by various observers, as the cause of "clover sickness." From what has already been said, there is little doubt that "clover sickness" is due to a variety of causes, and not to any *single* parasite (animal or vegetable).

(3) THE PARASITES OF LUCERNE (*Medicago sativa*).

The animal and vegetable foes of lucerne are the same as those which infest clover, consequently they do not require special description.

(4) THE PARASITES OF THE PEA (*Pisum sativum*).

The Pea Moth (*Grapholitha pisana*, Fig. 7). During the month of June this small moth will be seen hovering about the flowers of field and garden peas. According to Dr. Taschenberg (*Praktische Insekten-Kunde*), the female moth lays three eggs on each young pea-pod. In about a fortnight the eggs are hatched, and the larvæ or caterpillars, which are provided with mouths well adapted for chewing hard substances, gnaw their way into the pod, and then begin to regale themselves upon the "fleshy" cotyledons of the seeds (Fig. 7 B).

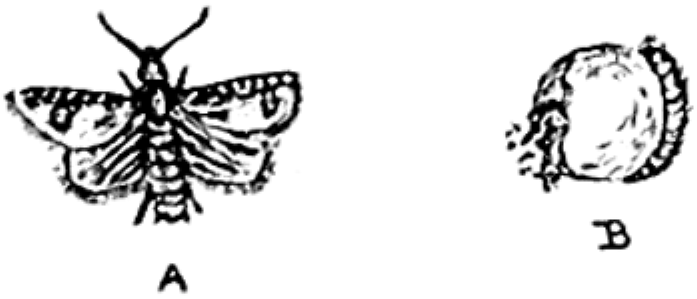

Fig. 7.—PEA MOTH (*Grapholitha pisana*).
A. Pea Moth (slightly enlarged).
B. Caterpillar eating pea (nat. size).

The caterpillars of this moth are of a yellow colour, with black heads. Their bodies are divided into segments, and each segment has a certain number of brown dots and a few hairs. The caterpillars finally retire to the earth, where they change their skins, and ultimately spin cocoons. Within these cocoons they hibernate until the following spring. During the spring they pass into pupæ, and appear finally as moths (Fig. 7 A) about the month of June.

The larva of the pea moth causes what is known as "maggoty" or "worm-eaten" peas.

Prevention. — (1) Deep-digging or ploughing, before winter, is effectual in destroying the pupæ of this moth. (2) Raking over the ground after the pea crop has been gathered brings the caterpillars to the surface. These are sure to be cleared away by birds. (3) Rotations of crops.

Cure.—(1) It has been stated that either quicklime, sulphur, or soot placed along the rows of peas, after a shower of rain, has proved effectual in keeping off an attack of this insect. (2) Syringing the plants (at the end of May) with a mixture of paraffin oil and water destroys the pest.

The Pea Beetle (*Bruchus pisi*) belongs to the same genus as the bean beetle (already mentioned), and follows a similar life-history. The larva is white.

The Pea Weevils (*Sitona crinita* and *Sitona lineata*). These small beetles (Fig. 8 A) devour the *leaves* of pea and bean crops, by eating everything except the woody midrib. *Sitona lineata* (Fig. 8 B) is the largest of the two species, is of a yellow colour, and has about ten dotted stripes along the elytra. The legs and antennæ are of a red colour. *Sitona crinita* is smaller than the preceding species. It has grey elytra, spotted with black, and covered more or less with hairs. These beetles feed during the day, and at night retire to rest in the ground. They are very sensitive to sound, and if approached they usually drop from the leaves to the ground. The *Sitones* pair in May, and a little later the females deposit (?) numbers of white eggs.[1]

Prevention. — Liberal manuring engenders a healthy and vigorous growth. This may be a means of preventing serious injury to the young pea-plants.

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[1] **Little is known of the larval and pupal stages of these beetles.**

Cure.—(1) As the beetles retire to the ground at night, treat the ground with lime, gas-lime, soot, or a mixture of lime and soot. These substances destroy the beetles. (2) Paraffin oil mixed with soil has also proved an effective remedy against the ravages of these beetles.

The Silver Y Moth (*Plusia gamma*). The caterpillars of this moth, which are of a green colour, feed upon the leaves of peas, beans, sugar-beets, linseed, and hemp. Towards the end of the caterpillar stage, each caterpillar spins a cocoon on a leaf of the infested plant, and in it changes into a chrysalis. *Plusia gamma*, in any one of the three stage of its life, rarely does much damage to crops in Great Britain, although, according to Dr. Lindeman,

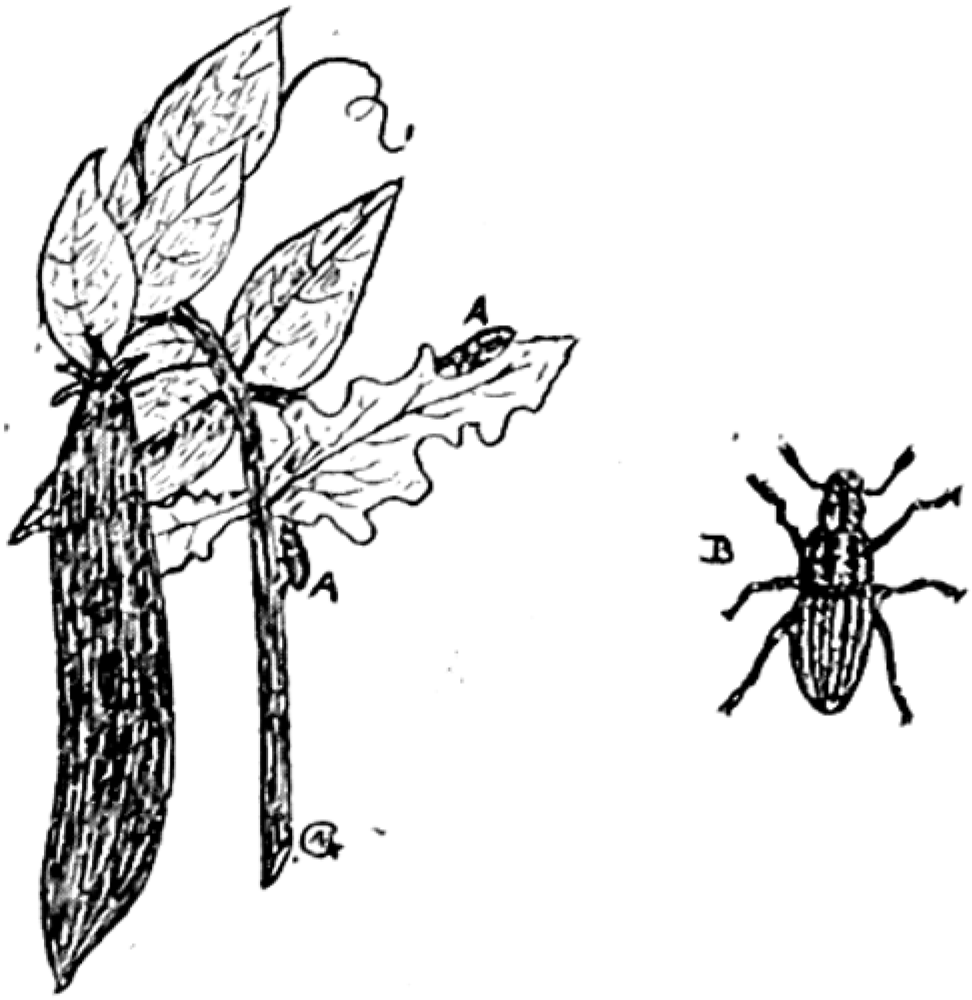

Fig. 8.—Striped Pea Weevil (*Sitona lineata*).

A. Pea Weevil (natural size) devouring leaves of pea-plant.
B. Pea Weevil (enlarged).

the larva of this insect causes considerable damage to the crops of Russia.

Prevention.—As the caterpillars feed upon nettles and low-growing grasses, these should be cleared away.

Cure.—A good dusting with lime or soot is a sure remedy for this pest.

The Pea Mildew (*Erysiphe Martii*, Fig. 9) is very destructive, as it "grows on both sides of the leaves," causing white spots. The spores of this fungus throw out hyphæ, which are provided with suckers. These suckers (haustoria) pierce the epidermis of the host-plant, and thereby impede its growth. The hyphæ soon produce a mat-like mycelium within the leaves of the pea-plant. During the early summer the mycelia give rise to a number of vertical groups of conidia or spores (Fig. 9 A).

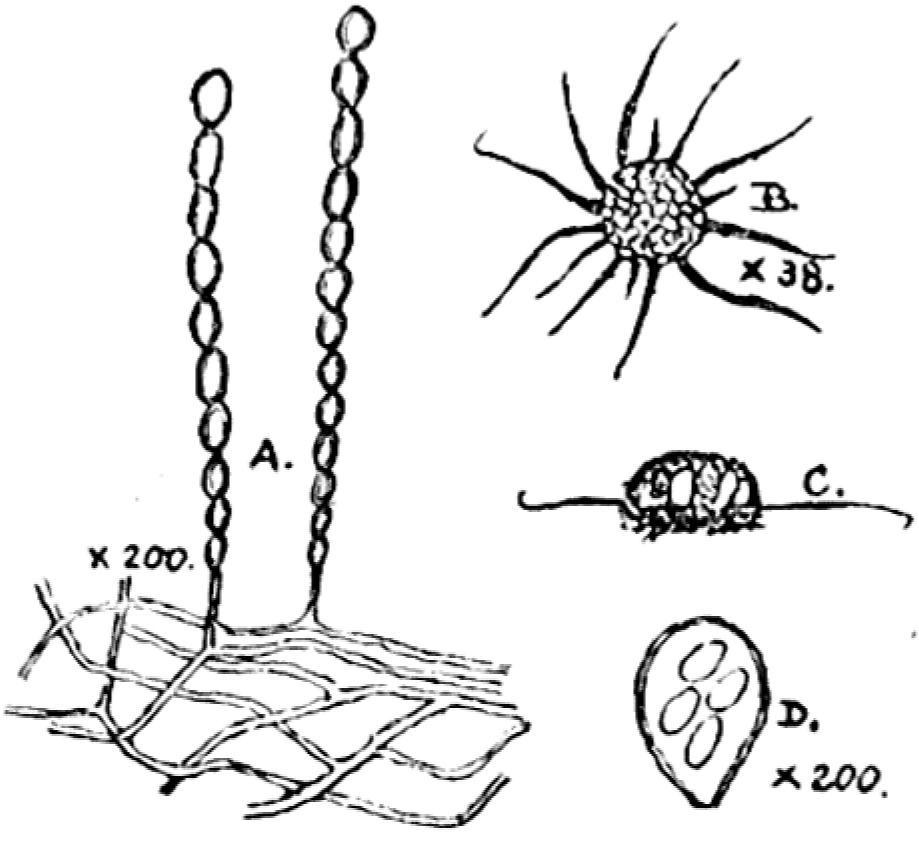

Fig. 9.—Pea Mildew (*Erysiphe Martii*).

A. Oidium stage of the Pea Mildew, showing mycelium and spores.
B. Conceptacle, or the perfect stage of the mildew.
C. Section of the conceptacle, showing asci containing spores.
D. An ascus with spores.

The formation of mycelia and spores constitutes the first stage of the life-history of the pea mildew.

Later, and under favourable circumstances, the mycelia produce a number of globose bodies (the conceptacles or perithecia) of a brown colour. Under the higher powers of the microscope the conceptacles are similar in appearance to Fig. 9 B. Within each conceptacle there are a number of oval-shaped bodies (asci) containing spores (see Fig. 9, C and D). After a time these conceptacles fall to the ground and hibernate until the following spring or early summer. Then they burst, and the spores are set free, to be wafted about by air-currents, until they fall upon a suitable medium for germination to take place. These spores produce the mycelium of the first stage of the life-history of this fungus.

Erysiphe Martii causes immature decay, besides seriously interfering with the processes of transpiration and assimilation, and thereby prevents the growth of the host-plant. This fungus attacks beans, melilot, peas, and other plants.

Prevention.—(1) Destroy all infested matter from the previous year's crops. (2) Clear away weeds, and destroy them by fire. (3) As the fungus has been seen growing inside the pods of peas, steep the seed peas before sowing in a solution of iron sulphate (1 lb. of iron sulphate to a gallon of water). This will destroy the conceptacles and spores of the fungus.

The Pea Mould (*Peronospora viciæ*, Fig. 10) is the fungus which causes brown spots on the leaves of the pea-plant and other legumes. "Damp, close weather favours the extension of this fungus, and dry weather retards its growth." The life-history of *P. viciæ* is similar to that of the clover mildew already described. Like all the *Peronosporeæ*, it grows internally in living plants, "sucking" their juices, and thereby causing disease.

Prevention.—(1) Destroy all refuse from the pea crop, as it harbours the resting-spores of this fungus. (2) Farm-yard manure, from cattle fed on vetches and peas, should not be used for manuring land required for peas and vetches. The reason of this is, that the resting-spores of the fungus, if present on vetches and peas, pass through the alimentary canal without being destroyed.

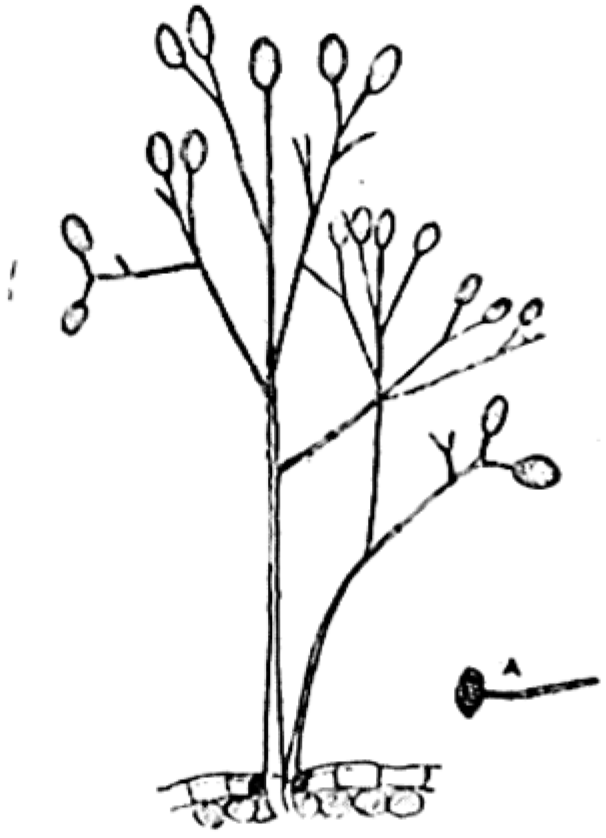

Fig. 10.—Peronospora viciæ.

The mould of vetches and peas (causing brownish patches on the leaves, etc.). A. Spore germinating, × about 154.

Cure.—When the crops are above ground, give them a top-dressing of iron sulphate ($\frac{1}{2}$ cwt. per acre). This generally destroys most fungoid growths.

(5) The Parasites of Trefoil (*Medicago lupulina*).

Several parasites which attack clover are foes of trefoil.

The Trefoil Weevil (*Apion flavipes*, Fig. 11) belongs to a large family (*Apionidæ*) of small beetles. Many of them do not exceed one-eighth or one-twelfth of an inch in length. They are wingless, but possess well-developed wing-cases (elytra). Both the head and thorax are comparatively small and narrow. The former is prolonged into a rostrum (snout) of considerable length. The antennæ form lateral appendages to the rostrum (Fig. 11 B).

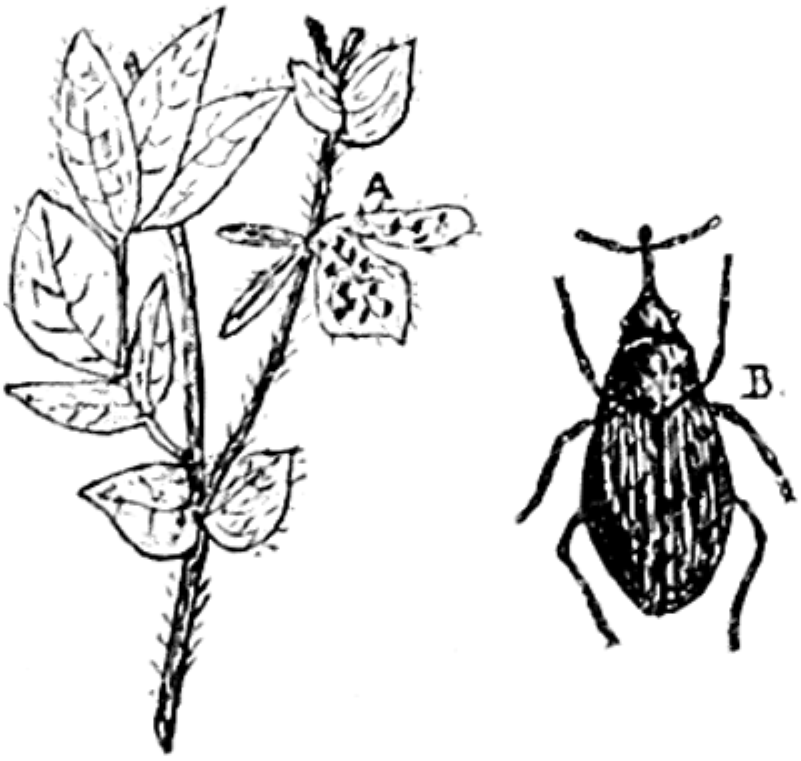

Fig. 11.—Trefoil Weevil (*Apion flavipes*).

A. Larvæ of *Apion* feeding on trefoil.
B. The beetle (enlarged).

The wing-cases are of various hues (green, blue, black, or red).

The larvæ (Fig. 11 A) of *Apion flavipes* feed on and are very destructive of trefoil. The perfect insect (imago) is black, with red legs.

Prevention.—Liberal manuring and the use of soot and lime tend to lessen the attacks of this insect.

The Trefoil Moth (*Zygæna trifolii*). "This moth flies about in the day-time, and has deep metallic green or blue fore-wings marked with several roundish, bright-red spots." The larva (caterpillar) feeds upon the *leaves* of trefoil and various herbaceous plants.

(6) THE PARASITES OF VETCHES OR TARES (*Vicia sativa*).

The parasites of this crop are similar to those of the pea. *Peronospora viciæ*, already described under the name of the "pea mould," attacks *Vicia sativa* as well as other plants.

So far we have surveyed the life-histories of the principal parasites which injure *leguminous crops.* To conclude this part of the subject we quote from Professor P. J. Van Beneden's *Animal Parasites and Messmates* (English edition, p. 85): "The parasite is he whose profession it is to live at the expense of his neighbour, and whose only employment consists in taking advantage of him, but prudently, so as not to endanger his life. He is a pauper who needs help, lest he should die on the public highway; but who practises the precept—not to kill the fowl in order to get the eggs. . . . The beast of prey kills its victim in order to feed upon his flesh, the parasite does not kill; on the contrary, he profits by all the advantages enjoyed by the host on whom he thrusts his presence."

CHAPTER III.

THE DISEASES OF ROOT CROPS.

(1) The Parasites of Beetroot (*Beta vulgaris*).

The Beet Fly (*Anthomyia betæ*, Fig. 12). The larvæ of this insect feed upon and burrow into the tissues of the leaves of beet plants, causing great destruction to the crops. They are about one-third of an inch long, and are devoid of legs. The eggs (Fig. 12 B) are small, oval, white bodies with hexagonal-like markings. They are laid on the under surface of the leaves, and when hatched (*i.e.*, in five days) the grubs attack the parenchyma or soft parts of the leaves, and thereby interfere with the life and nourishment of the plant.

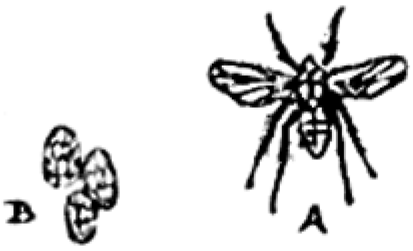

Fig. 12.—Beet Fly (*Anthomyia betæ*).
A. Beet Fly (nat. size).
B. Eggs, × 4.

Under favourable circumstances, during the summer, the perfect insect (Fig. 12 A) is developed from the pupal stage in about fourteen days; but if the transformation from the larval to the pupal stage occurs late in the season, the pupa hibernates in the ground until the following season. Pupation *may* also take place on the leaves. The beet-fly attacks the plants in the following manner: "After the beet plants have been singled and begin to show vigorous growth, with broad leaves, they suddenly droop, and have a withered appearance. Upon examination it will be found that there are white blotches, like blisters, upon the leaves, caused by maggots lying snugly within their tissues, from which they have exhausted the juices and extracted the chlorophyll, or green colouring." "The perfect insect is about the size and shape of a common house-fly. It is dark-grey, with black hairy legs, having yellow antennæ with black tips. The femora (thighs) of the female are yellow."

Prevention.—(1) Before growing a crop of beetroots plough in a green manure of *buckwheat.* This destroys the pupæ of the beet-fly. (2) An observer in the *Agricultural Gazette* (Aug. 18th, 1884) writes: "Any fertilizing application will do good which will act at once in furnishing nourishment to the plant, and thus keep it continually replacing by new growth the leafage which is destroyed by the maggots. Nitrate of soda appears to do best; but as the action of fertilizers depends on having rain at the time to wash them down to the roots, it is better to have previous good treatment of the land to trust to." (3) "Many weeds (thistles, sow-thistles, dandelion, etc.) serve as breeding-places for this insect, and should therefore be kept from the neighbourhood of dung heaps and beet or mangel fields."

Cure.—Wash the plants with mixtures of mineral oil and a solution of soft soap. The proportions of this mixture are 5 lbs. of soft soap and from 1½ to 2 gallons of paraffin oil to 100 gallons of water. This should be "put on with the ordinary hop-washing machine, like a garden-engine, with a long hose attached to it, or with the Strawsonizer."

The Beet Carrion Beetle (*Silpha opaca*, Fig. 13) is found during the spring on putrefying animal matter (hence the name "carrion"), the roots of trees, etc. The beetles are of a dark-brown colour. On opening the wing cases, the posterior end of the abdomen is of a dull-red colour. The female lays the eggs in decomposing matter, and these give rise to larvæ, which attack and seriously injure the young leaves of beet plants. In appearance the black larvæ are somewhat like the ordinary wood-lice, only smaller (Fig. 13 B). They turn to the pupal stage in the ground.

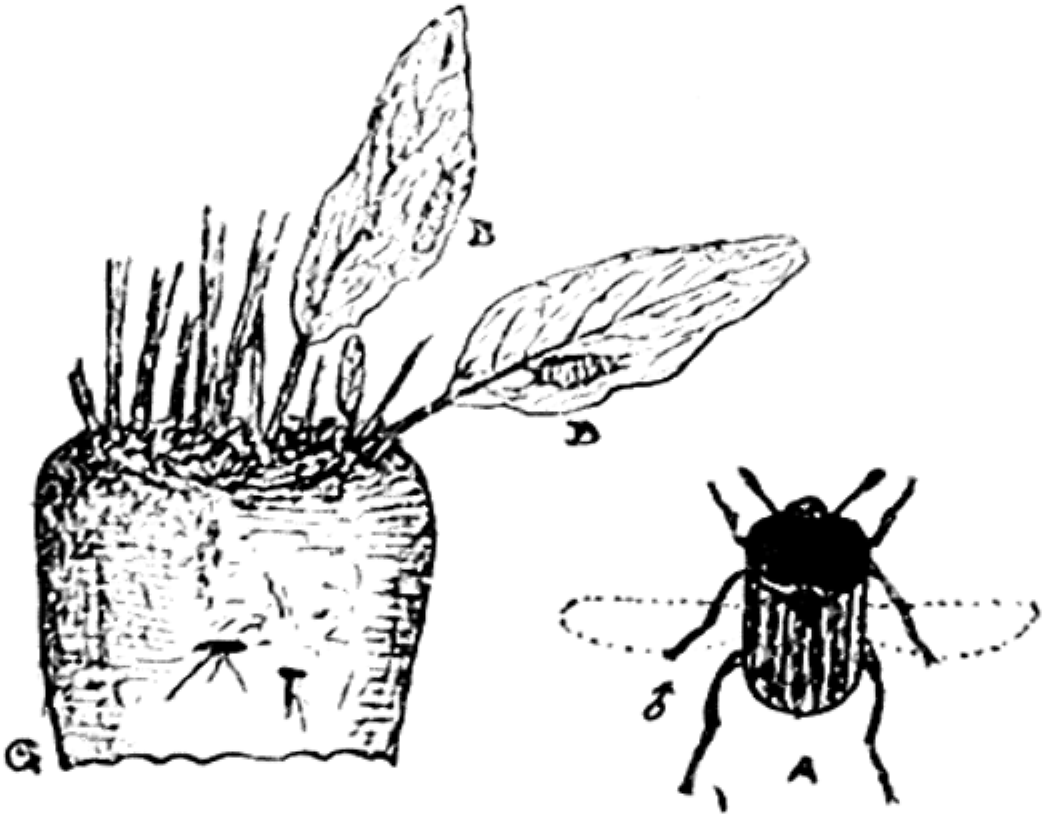

Fig. 13.—Beet "Carrion" Beetle (*Silpha opaca*).

A. The beetle (about the size of nature).
B. Larvæ (nat. size) feeding on leaves of beetroot.

Prevention.—(1) Liberal manuring in the *early* stages of growth is a means of preventing the attacks of this pest. (2) The farmyard manure used for this crop should be thoroughly fermented.

Cure.—Top-dress the plants with sulphur or a mixture of lime and soot.

The Silver Y Moth (*Plusia gamma*) rarely causes much injury in Great Britain, although the green caterpillars of this moth cause considerable damage to the leaves of sugar-beets in the northern provinces of France. During 1887 the author saw several crops damaged by *Plusia gamma* in the suburbs of Paris.

The colour of the moth is silver-grey, with brown markings. The eggs are laid in clusters on the under surfaces of the leaves, where they are hatched in about a fortnight.

Prevention and Cure.—See under the heading of "The Parasites of the Pea" (chap. ii.).

The Nematoid of Beetroots (*Heterodera Schachti*) causes considerable damage to the roots of this crop. It is a dimorphous worm; "the male has the usual form, the female resembles a lemon" (*Schacht*).

The Beet-leaf Rust (*Trichobasis betæ*) is a fungoid growth, which causes yellow spots on the leaves of beets, and ultimately ruptures the epidermis of the host-plant. The spores are brown, and the fungus is common in August and September.

(2) THE PARASITES OF CARROTS (*Daucus carota*).

The Carrot Fly (*Psila rosæ*, Fig. 14). The maggots of this insect gnaw and burrow into the roots of this crop. These burrows have the colour of iron rust. The leaves of the invaded crops prematurely turn yellow, owing to the diseased condition of the roots and the lowered vitality of the plants. After a time the roots shrivel.

The white maggot (Fig. 14 B) is legless, and is about a

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quarter of an inch long. The maggot turns to the pupal stage in the ground. During the summer the pupæ are transformed into perfect insects in about twenty-five days. The female flies finally give rise to eggs, maggots, and pupæ; the latter hibernate in the ground until the following spring. The yellow body of the fly is about a quarter of an inch long, and carries two wings of a blackish-green colour.

Prevention.—(1) Good cultivation. (2) After thinning top-dress the crops with soot and nitrate of soda.

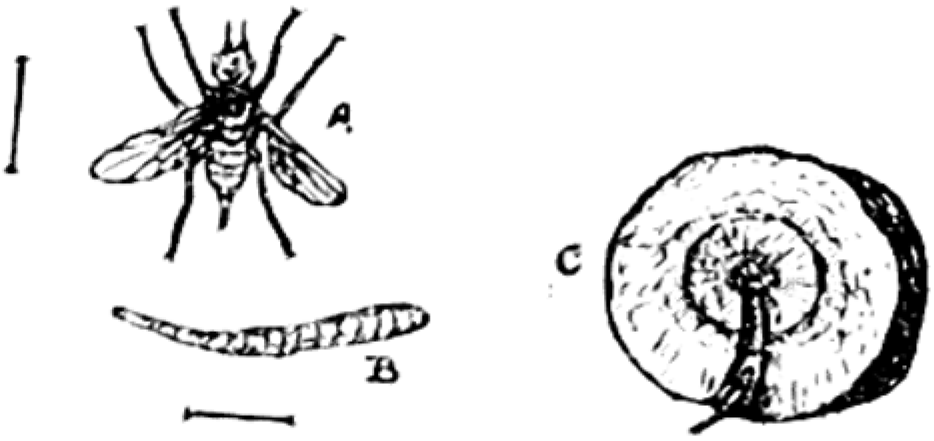

Fig. 14.—Carrot Fly (*Psila rosæ*).

A. Carrot Fly (enlarged).
B. Legless larva (enlarged).
C. Transverse section of a carrot, showing a "burrow" made by the larvæ of Psila.

Cure.—(1) Mix one pint of paraffin oil with two gallons of water, and water the plants with the mixture after thinning. (2) Top-dress the crops with sand saturated with paraffin oil. (3) "An injured crop should be lifted early, the ground thoroughly limed and deeply ploughed. This destroys the pupæ, and prevents a renewal of the attack in some future season." (4) Farmyard manure, mixed with salt and ploughed into the land during the autumn, destroys the pupæ.

The Carrot Milliped (*Julus terrestris*, Fig. 15) is one of the so-called "false wire-worms," and is one of the largest British species. It attacks carrots, parsnips, and other root crops.

The *Juli* undergo a sort of metamorphosis, coming from the egg either quite destitute of feet or furnished with only three pairs of these organs. According to Dr. Savi, the *Juli* occupy two years before the sexual organs are perfected.

Prevention and Cure.—Green manuring with buckwheat destroys this pest.

The Carrot Moths (*Depressaria daucella*, *Depressaria depressella*, and *Depressaria cicutella*) lay their eggs on the foliage of this crop, and the caterpillars damage the leaves and the heads of the flower. "When disturbed they drop to the ground, and after a time, by means of a gossamer thread left for the purpose, they return and renew their depredations." The caterpillars of the two first-mentioned species feed on the flowers and seeds of the carrot plants. The larvæ spin webs so as to fasten the umbels together, and then regale themselves, destroying the flowers of the host-plant. The caterpillars of both *D. daucella* and *D. depressella* are greenish-grey in colour. The former are about half an inch and the latter a quarter of an inch long. When full-grown, both species change to the pupal stage in the flower-heads, or they

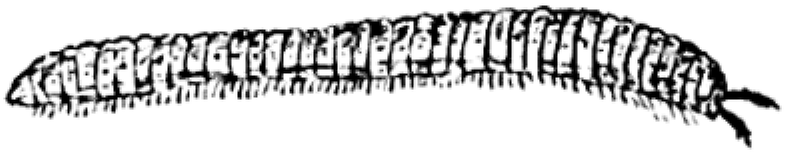

Fig. 15.—"CARROT MILLIPED" (*Julus terrestris*).
Nat. size.

hibernate in the stems of the carrot plant until the following spring. The moth of the first-named species is about half an inch long, of a red-brown colour; while the moth of *D. depressella* is the same length, but of a yellow colour.

The caterpillars of *D. cicutella* feed on the leaves of the carrot plant, which they roll up. These caterpillars are green in colour with black spots on each segment, and they are half an inch long. The pupæ are brown, and are to be found either in the coiled leaves or in cocoons in the ground. The moths are about seven-sixteenths of an inch long, with narrow wings of a reddish hue. They make their appearance in June.

These three moths are known under the popular names of "the carrot-blossom moth," "the purple carrot-seed moth," and "the common flat-body moth," respectively.

Prevention.—Burn all infested stems, etc.

Cure.—Use dressings of soot, quicklime, or sulphur.

The Swallow-tailed Butterfly (*Papilio machaon*) is a rather rare and brilliant creature. The colour of the wings is yellow and black, with lines and spots, a deep bluish-black band near the hind margin, and a bright red round spot on the inner margin of each hind wing. It is chiefly found in the *fenny* districts of Lincolnshire, Huntingdonshire, and Cambridgeshire. The larva or caterpillar of this butterfly is of a pale green colour with black bands and orange spots. It feeds on the leaves of carrot plants.

Prevention.—Destroy cow-parsnip and other umbelliferous plants.

(3) THE PARASITES OF MANGEL-WURZEL (*Beta maritima* and *Beta vulgaris*).

The Mangel Fly (*Anthomyia betæ*) has already been described. It destroys the foliage, and thereby arrests the growth of the plant.

Cure.—Mr. C. Whitehead, F.L.S., recommends washing the leaves, by means of a garden engine, with a solution of soft soap and quassia.

The Carrion Beetle (*Silpha opaca*), already described, injures mangel-wurzel as well as beetroot.

The Club-Root of Mangel (*Plasmodiophora brassicæ*) is a fungoid growth which will be described later on in this chapter (see "The Parasites of Turnips").

The Mangel-Leaf-Rust (*Trichobasis betæ*) has already been described among the diseases of beet-roots.

(4) THE PARASITES OF ONIONS (*Allium cepa*).

The Onion Eelworms (*Tylenchus allii*), according to Dr. Ritzema Bos, cause putrefaction to occur within the bulbs. They are found in the parenchyma of the bulbs and leaves. Much injury is done by these pests to the onion crops of Holland.

Prevention and Cure.—See "The Eelworms of Clover" (chap. ii.).

The Onion Fly (*Anthomyia ceparum*) belongs to the same genus as the beet fly. The eggs are laid in April or May, on the lower leaves of the young onion plant or on the ground. After hatching, the larvæ, which are devoid of legs, and about three-eighths of an inch long, feed *inside* the bulbs, having previously gnawed a way into the interior. Here they reside from fourteen to sixteen days, causing a considerable amount of damage to the bulbs, which finally become rotten. After the expiration of a fortnight's residence within the bulb, they leave it and enter the ground, and there turn to the pupal stage. If the grub turns to the pupal stage in the *autumn*, it hibernates until the following spring. If, on the other hand, it becomes a pupa during the *summer*, it remains in this state from fourteen to twenty-one days, when it becomes a perfect insect. The fly is nearly five-eighths of an inch across the extended wings. The male is grey in colour, with three dark bands on the abdomen; while the female is of a yellow colour.

Prevention.—(1) Rotation of crops. (2) "The most successful method of cultivation is to trench the ground for the onions in the autumn, working plenty of manure into the soil, or placing a good layer at the bottom of the trench." (3) Raise all sickly-looking plants by means of a spud. This will decrease the number of grubs, etc.

Cure.—(1) Applications of paraffin oil mixed with water (1 pint to 2 gals.) have been the means of destroying this pest. (2) Soap-suds have also been recommended as a remedy. (3) Soot, sulphur, and lime are powerful insecticides.

The Putrefactive Microbe of Onions (*Bacterium allii*, Fig. 16). It may be useful, in passing, to allude to a microbe which is a destroyer of onions (*when stored*), by causing putrefactive changes to occur within the bulbs. This putrefaction ultimately gives rise to a greenish-coloured slime over the surface of the decomposing onions. This microscopic organism must therefore be looked upon as an enemy of the farmer, market-gardener, and others.

The author discovered this microbe upon onions kept in a warm, damp, and dark place. The cells are each about 0·005 to 0·007 millimetre long, and about 0·0025 millimetre[1] wide. The organism has been called *Bacterium*

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[1] 1 millimetre = 0·03937 inch.

allii, because it was discovered upon *Allium cepa.* It grows tolerably well in sterilized nutrient agar-agar (Japanese isinglass), and other cultivating media used by scientists. Upon the surfaces of nutrient media, *B. allii* produces a bright-green pellicle, and causes certain chemical changes to occur in albuminous substances. The microbe is chromogenic; *i.e.*, it produces a pigment (of a green colour), by the decomposition of the medium upon which it lives.

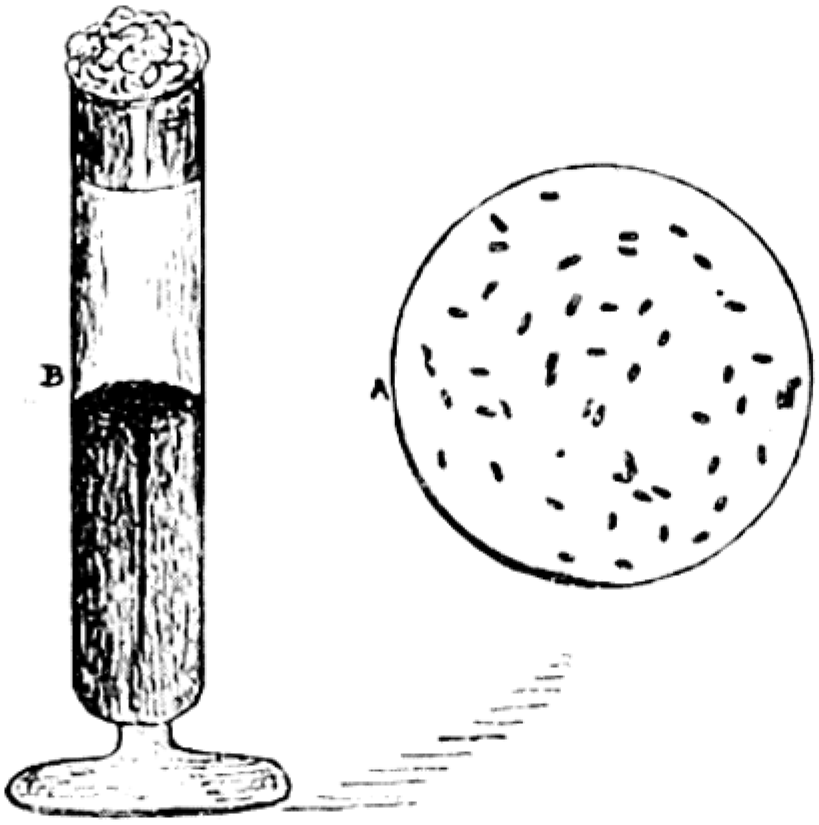

Fig. 16.—Putrefactive Bacterium of Onions (*Bacterium allii*).
A. The Bacterium under the high powers of the microscope.
B. *Bacterium allii* growing on nutrient agar-agar.

It appears that the whole function of this organism is to decompose or disintegrate albuminous substances, giving rise to certain products; *viz.*, sulphuretted hydrogen gas (in small quantities), and a deliquescent alkaloid of the following symbolic formula, $C_{10}H_{17}N$.

Bacterium allii is possessed of great tenacity of life, for after an exposure to 32° C. (dry heat) for six months the organism had not lost its vitality. Cold appears to reduce its vitality considerably. When artificial cultures were exposed to a temperature of -17° C. for one day, the organisms were completely destroyed. An E.M.F.[1] of 3·3 volts (at 17° C.) destroyed *B. allii* when growing in sterilized pork broth (neutral).

Prevention.—Onions, *when stored*, should be kept in a perfectly dry place, or they may become a prey to this microbe.[2]

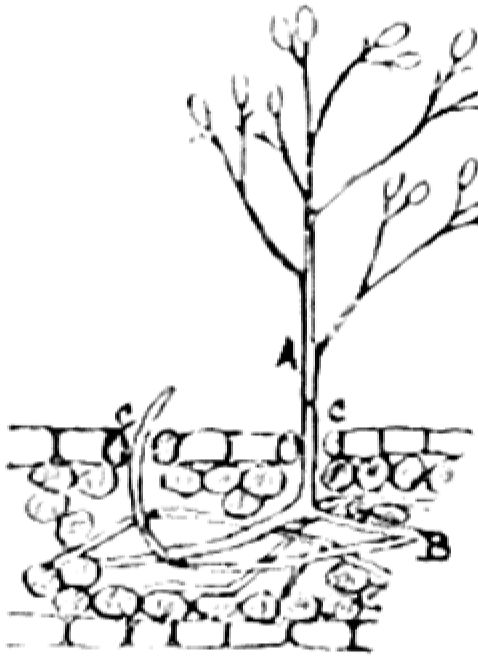

Fig. 17.—ONION MILDEW (*Peronospora Schleideniana*).

A. The fungus growing from the base of an onion leaf.
B. Mycelium ramifying amongst the cells of the host-plant.
C. Stomata of leaf.
D. Conidia (spores).
(× 50 diameters.)

The Onion Mildew (*Peronospora Schleideniana*, Fig. 17). This fungus is closely allied to *Peronospora infestans* (the potato-disease fungus), and, like all the members of the *Peronosporeæ*, grows within the leaves and stems of the host-plant. The onion mildew causes putrefaction among the microscopic cells of the leaves, etc., as well as greatly interfering with the processes of transpiration and assimilation. The onion mildew produces moist, greyish spots on the leaves of various species of *Allium*, or, in other words, causes, by contact, the complete decomposition of the leaves.

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[1] An electro-motive force (see any small text-book on electricity).

[2] For further information see Dr. Griffiths' papers in the *Proceedings of the Royal Society of Edinburgh*, vols. xv. and xvi.; and *Comptes Rendus*, vol. cx.

The mycelium (Fig. 17 B) ramifies amongst the living cells of the leaves. It produces conidiophores (Fig. 17 A) which bear aërial conidia (spores) Oöspores or resting-spores are produced by sexual reproduction, *i.e.*, by the union of the antheridium with the oögonium, similar to those already described in connection with the clover mildew (see chap. ii.). The oöspores are found in decaying onions.

Prevention.—(1) Burn all decomposing onion refuse. (2) Good cultivation, with the seeds sown in the autumn, produces strong healthy plants capable of withstanding the attacks of this fungus in the following spring. (3) Deep trenching.

Cure.—Manure the land, when the plants are a few inches above ground, with half-cwt. of iron sulphate per acre. The sulphate may be mixed with five to ten times its weight of sand or dry earth, in order to obtain regular distribution.

The Smut of Onions (*Urocystis cepulæ*) is allied to the "smuts," etc., of corn, potatoes, and other plants. It is more common in the United States of America, and in France, than in this country. It produces amongst the onions a blackish-brown dust after the harvest.

The Onion Mould (*Mucor subtilissimus*) grows on *Alliumcepa*, and possibly on allied plants. Another species of the *Mucorini* is the mould of preserved fruits, etc.

The onion mucor produces a very fine mycelium, which ramifies chiefly in the upper part of the bulb, causing decay. Among this mycelium are numbers of black grains —the sclerotia, or masses of mycelia in a resting state. Each sclerotium germinates by throwing out hyphæ which ultimately give rise (at their ends) to sporangia containing oval sporidia (spores). The sporangia, when ripe, burst in the air, and the spores are wafted about by air currents, causing destruction to crops of onions. The spores germinate on the host-plant, giving rise to hyphæ, mycelia, and sclerotia. The latter are capable of retaining their vitality through the winter months, and germinate in the spring.

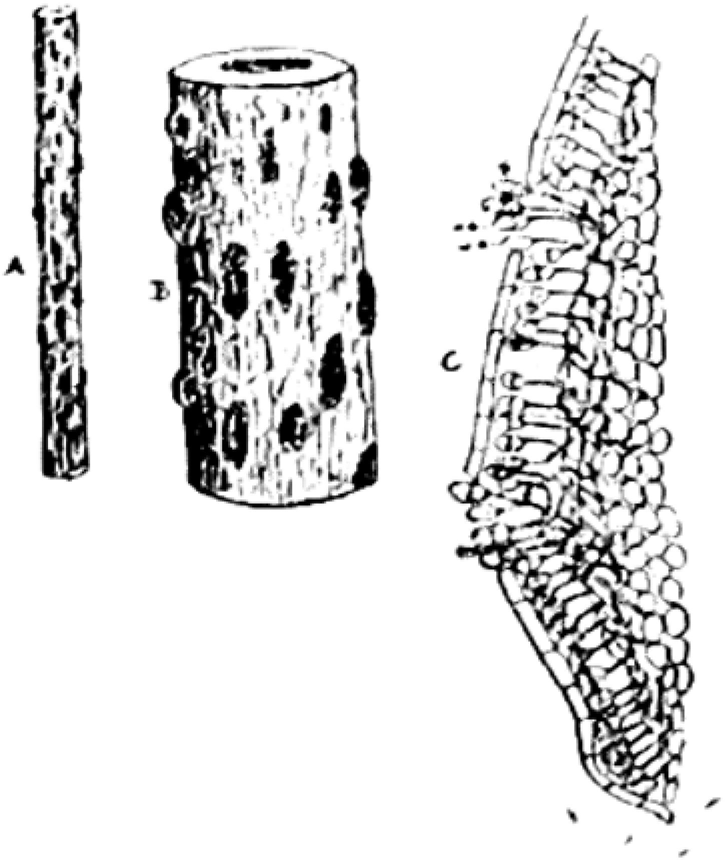

Fig. 18.—"GARLIC RUST" (*Puccinia mixta*).

A. Flower stalk (⅓rd nat. size) showing the disease "pustules" or sori.
B. The same × 4 diameters.
C. Transverse section of small sorus. The epidermis of host-plant is broken at 3 and 4, by the fungus whose mycelium is thickly matted amongst the tissues of host.
1 and 2 show the two kinds of spores × 75.

Prevention.—(1) Burn all infested onion refuse. (2) Autumn sowing.

The Garlic Rust (*Puccinia mixta*, Fig. 18) was discovered by a well-known fungologist, Mr. W. Phillips, F.L.S. (*Gardeners' Chronicle*, July 14th, 1883), on *Allium schœnoprasum* (chives). The fungus covers the leaves and flower stalks (Fig. 18 A and B) with brown spots. These spots are caused by sori, or masses of spores, etc., which ultimately rupture the epidermis of the host-plant. Each sorus (Fig. 18 C) is composed of a thickly matted mycelium, which ramifies among the tissues of the host; and gives rise to a large number of brown bodies (more or less club-shaped), which are morphologically spores, although unlike the conidia of other fungoid growths. These spores are called teleutospores, and are true *resting-spores.* The teleutospores of the garlic rust are of two kinds (Fig. 18, 1 and 2). One is divided by a transverse septum, and the other is not so divided. These spores are capable of hibernating for several months.

Prevention.—Burn all infested refuse.

(5) THE PARASITES OF PARSNIPS (*Pastinaca sativa*).

The Parsnip Leaf Miner (*Tephritis onopordinis*). The members of the genus *Tephritis* are lively little flies; and the species about to be described is one-sixth of an inch long, of a brown colour, with green eyes, and two transparent wings. The female lays her eggs within the cuticle of the parsnip leaves, where they are hatched, producing little pale-green maggots, which cause large blisters upon the leaves. These blisters ultimately cause the complete decay of the leaves. The pupa of this fly is of a yellow-brown colour, and is found on the leaves of the parsnip and in the earth.

There are several broods during the year. The pupæ last produced, hibernate in the soil until the following spring.

Prevention.—(1) Curtis recommended a dressing of tar and sand to be put on the ground before sowing the seeds. The odour of the tar is so offensive to insects that they cannot endure soil impregnated with it. (2) Burn all infested leaves.

Cure.—Dressing the land with gas-lime, soot, and lime, destroys the pupæ of this pest.

The Parsnip Fly (*Psila rosæ*) has already been described in this chapter (see "Carrot Fly").

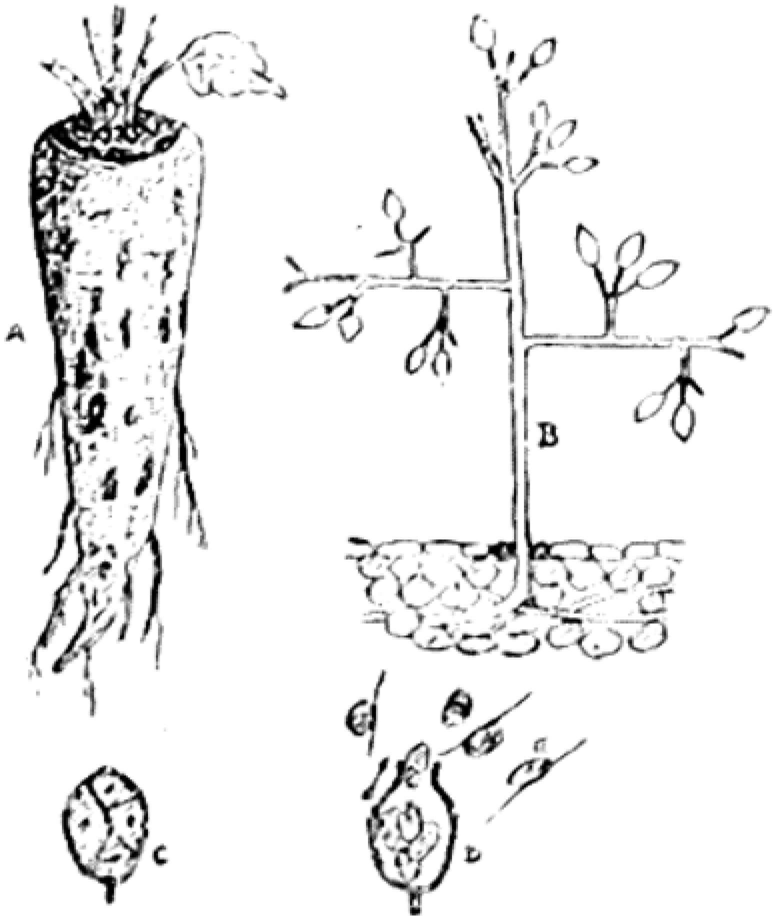

Fig. 19.—Mildew of Parsnips (*Peronospora nivea*).

A. A spotted parsnip.
B. Conidiophore bearing conidia (spores). × 107.
C. Mature conidium dividing. × 334.
D. Conidium after division. The formation of zoöspores. × 334.
E. Zoöspore with cilia. × 334.

The Parsnip Moths have already been described under the heading of "Carrot Moths"; and for still further information, see Dr. Riley's *Insect Life*, vol. 1, p. 94.

The Parsnip Mildew (*Peronospora nivea*, Fig. 19) lives within the tissues of the host-plant. The fungus first attacks the leaves, the hyphæ of which soon make their way into the stems and roots of the parsnip plants. The hyphæ, or threads of the mycelium, are stout, and are provided with numerous suckers, which cause putrefaction to occur within the tissues of the host-plant. When the roots are attacked, they become spotted (Fig. 19 A), and finally rotten. The mycelium sends out conidiophores (Fig. 19 B), bearing conidia, through the stomata of the leaves, and thereby interferes with the processes of transpiration and assimilation. The protoplasmic contents of the oval-shaped conidia (Fig. 19 C) divide into a number of portions, each of which produces a zoöspore (Fig. 19 D and E) provided with cilia (filaments), which enable them to be carried about by aërial currents. The zoöspores reproduce mycelia.

Oöspores (resting-spores) are produced, during the life-history of *Peronospora nivea*, within the stems and roots of the host-plant. This parasite of parsnips also attacks parsley and other plants.

Prevention.—(1) Burn all infested refuse from previous parsnip crops. (2) Destroy such weeds as cow parsnip, goutweed, wild chervil, and wild angelica.

Cure.—See the treatment of the potato disease caused by *Peronospora infestans.*

(6) THE PARASITES OF POTATOES (*Solanum tuberosum*).

The Colorado Beetle (*Leptinotarsa decemlineata*, Fig. 20) belongs to the *Chrysomelidæ*, and is about half an inch long, with wing-cases marked alternately in stripes of black and yellow. The thorax is also yellow with a black v-shaped mark in the centre, surrounded by several smaller black marks. If the elytra (wing-cases) are opened, the bright *red* wings will be seen; this is one of the peculiarities of this insect.

The female lays the eggs (Fig. 20 C) chiefly on the under surfaces of the leaves of the potato plant. When hatched, the eggs give rise to orange-coloured larvæ (Fig. 20 B). These feed upon the leaves, causing great havoc amongst the potato crops of the United States of America. The larvæ turn to the pupal stage in the ground.

The Colorado beetle appears to be indigenous to North America. Its original home was the Western States (Oregon, Nevada, Arizona, and Colorado); but it is now to be found in other States besides those mentioned, and most probably all over the North American Continent.

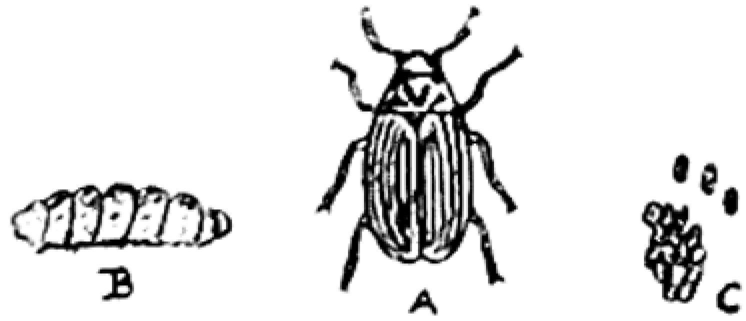

Fig. 20.—Colorado Beetle (*Leptinotarsa decemlineata*).

A. The beetle (nat. size).
B. Larva (nat. size).
C. Eggs (nat. size).

It was first identified in Great Britain by the late Mr. A. Murray, F.L.S., in 1877. Up to the present time British potato crops have not suffered from the ravages of this destructive beetle.

Cure.—Mix three ozs. of the arsenical compound (copper arsenite) known as "Scheele's green," with two gallons of water, and water the infested plants with the mixture. For other remedies and the *numerous appliances* for distributing the same,—see *The Fourth Report of the United States Entomological Commission* (pp. 120–321).

The Death's Head Moth (*Acherontia atropos*) is the largest moth in England, and, according to Swainson, the largest in Europe. It often measures from five to six inches across the extended wings. The skin of the moth is variegated with black, dark-brown and yellow; and bears upon the back of the thorax a deep orange mark, presenting no inconsiderable resemblance to the front of a human skull. *A. atropos* "utters" a sharp squeaking sound.

The larvæ (caterpillars) of this moth are also very large, often measuring from four to five inches long, and as thick as a man's finger. They feed upon the *leaves* of the potato plant during the evenings, but, according to Miss Ormerod, "seldom cause any serious amount of damage." They are provided with feet and strong jaws. The skin of the caterpillar is of a pale yellow colour, with seven oblique violet stripes along the abdominal segments. The larvæ change their skins, and are transformed into the pupal stage, at least one foot deep in the ground. For this reason they have been termed subterranean pupæ, and are often turned up in digging potato grounds. The pupa is chestnut coloured. The perfect insect makes its appearance from August to October.

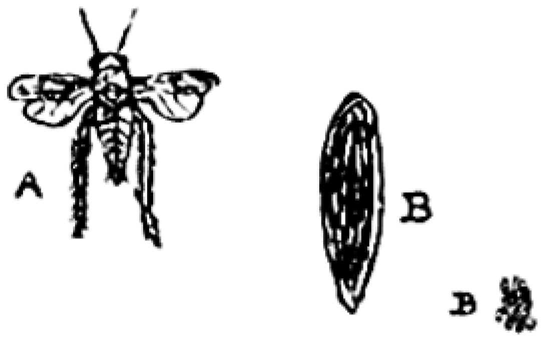

Fig. 21.—Potato Frog Fly (*Eupteryx solani*).

A. Frog fly (enlarged).
B. Eggs (nat. size and enlarged).

Prevention and Cure.—(1) Handpicking. (2) Liming the land destroys the pupæ.

The Potato Frog Fly (*Eupteryx solani*, Fig. 21) is a small green insect, measuring only one-sixth of an inch in length. It is provided with four wings, two *short* antennæ, placed between a pair of brown eyes. There are six legs. The posterior pair are very long, which assist the insect in performing most extraordinary leaps, —hence the name of "frog fly."

The eggs (Fig. 21 B) are white, and about one-twentieth of an inch in length. The larva and pupa are both somewhat like the perfect insect in shape, provided with six legs, two antennæ (long), and a sucker. They are wingless. ***Eupteryx solani*** (in all three stages) lives upon the juices of the leaves and stems of the potato plant, which it pierces by means of its sucker.

Cure.—A dressing of lime, sulphur, or soot.

The Potato Disease Fungus (*Peronospora infestans*, Fig. 22). The life-history of this fungus has been thoroughly investigated by Rayer, Montagne, Berkeley, De Bary, Smith, and others; but to Mr. W. G. Smith, F.L.S. (who discovered the reproductive organs and the oöspores), is the honour of having made a *thorough* study of this fungus.

The potato disease (the so-called "curl") makes its appearance in July or August, especially in moist warm weather; and commences its attack by settling upon the leaves of the host-plant. The leaves become spotted (blackish), and have a tendency to curl up. After piercing into the interior of the leaves, the fungus spreads its mycelium through the tissues of the stems and tubers of the potato plants. Its growth is very rapid, and it produces in the host complete decomposition of the parts in contact with it.

If a transverse section of a diseased potato leaf (Fig.

22) is examined beneath the microscope,[1] the mycelium of the fungus will be seen ramifying among the cells of the leaf. Wherever the mycelium comes in contact with the cells of the host-plant, they become discoloured. This is due to the putrefactive changes caused by the presence of this fungoid growth. The mycelium gives rise to aërial hyphæ (conidiophores) which bear conidia or spores (Fig.

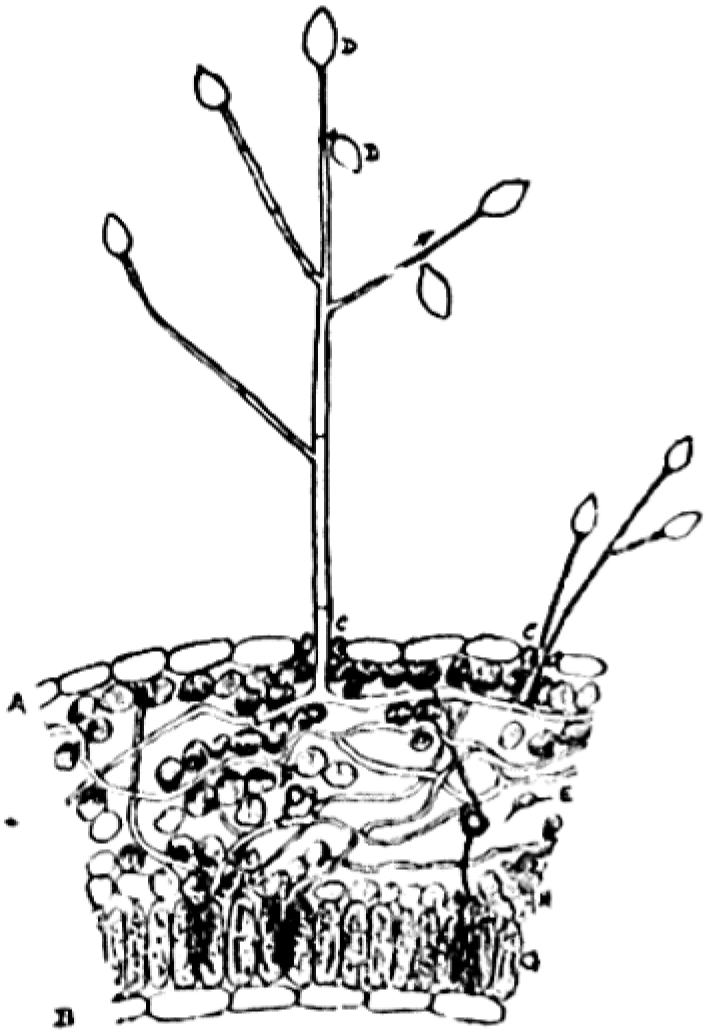

Fig. 22.—Potato Fungus (*Peronospora infestans*).

A to B. Transverse section of potato leaf, showing mycelium (spawn) of fungus.
A. Lower surface with two stomata (C) and conidiophores passing through them.
D. Conidium (spore).
E. Zoöspore.
F. Oögonium and antheridium.
G. Pallisade parenchyma cells of leaf.
H. Spongy parenchyma.
(× 100 diam.)

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[1] In our opinion, the best "objectives" for this and similar purposes are those made by Zeiss of Jena.

22 D); and to reproductive organs (Fig. 22 F) within the host-plant. The protoplasm of the conidia either divides or gives rise to a hypha or "germ tube" (Fig. 23). When it divides it produces a number of zoöspores provided with cilia (filaments) (Fig. 23 B). The zoöspores float about in the atmosphere and thereby spread the disease. Ultimately the cilia disappear, and the zoöspores settle down upon the leaves of the potato plant, giving rise to another generation of mycelia. According to the late Rev. M. J. Berkeley, F.R.S., the mycelium sometimes hibernates and becomes perennial. Sexual reproductive organs are formed from the cells of the mycelium within the host-plant. They are generally to be found in the intercellular spaces (Fig. 22 F, and Fig. 23 D). Fertilization

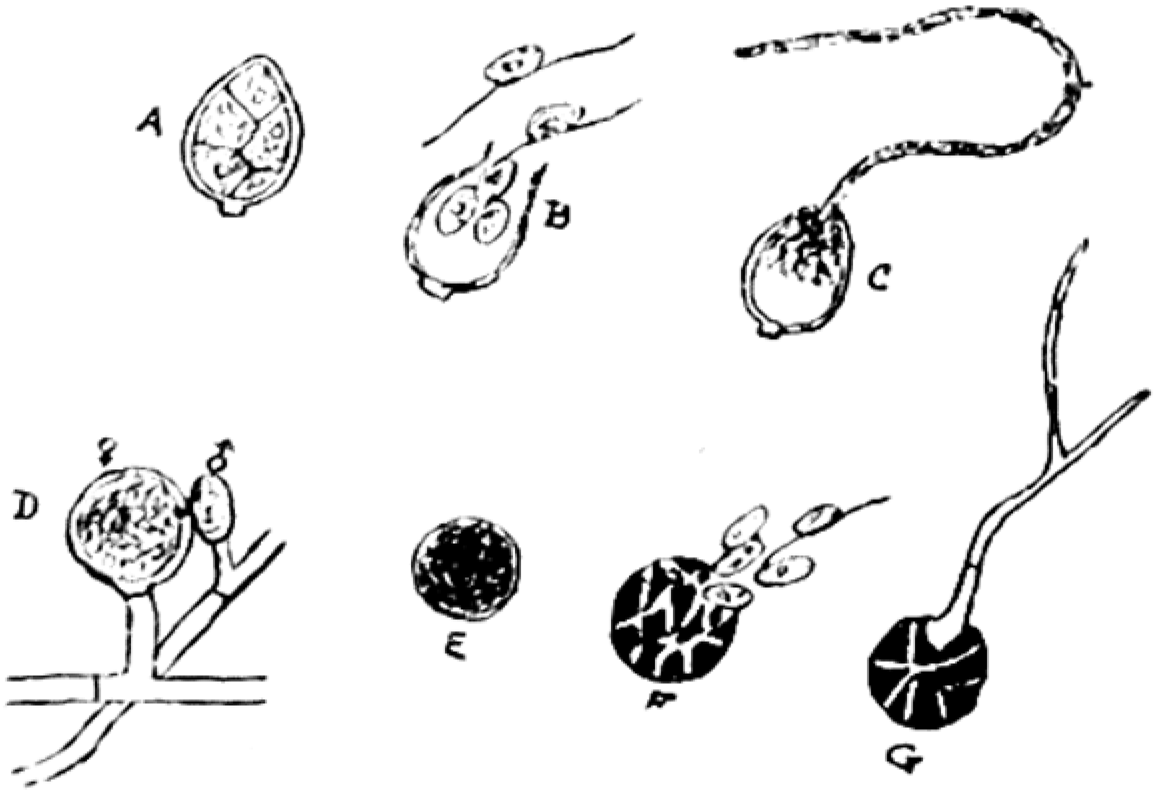

Fig. 23.—Potato Fungus (*Peronospora infestans*).

A. Conidium dividing.
B. Conidium producing zoöspores (after division).
C. Conidium protruding a filament of protoplasm.
D. Oögonium (♀) and antheridium (♂).
E. Oöspore (Resting-spore).
F. Oöspore producing zoöspores.
G. Oöspore germinating.
(× 300 diam.)

takes place by the transfusion of the contents of the antheridium into the oögonium. After fertilization, the oögonium develops into an oöspore (Fig. 23 E). The outer coat of the oöspore thickens and may become "spiny." The oöspore hibernates for nearly a year, and then gives rise to zoöspores or germinates by throwing out a hypha (Fig. 23 F and G). The zoöspores and hyphæ from the oöspore reproduce the disease in the next year's crop, if the external surroundings are favourable for their development and growth.

The author has shown (*Chemical News*, vol. 53, p. 255) that the spores, etc., of *Peronospora infestans* are capable of being dried up in the dust of the atmosphere for several months without losing their vitality. On the other hand, if potato tubers infested with the mycelia of this fungus are exposed to a temperature of – 10° C. (14° F) for a few weeks, they are completely destroyed. *Peronospora infestans* causes (as stated before) putrefactive changes to occur within the tissues of the host-plant. The author found lactic acid (in small quantities) in the leaves, etc., of *diseased* potato plants. It may be that lactic acid is formed from the decomposition of glucose contained in the sap of the host-plant. From this it appears that parasitic fungi may cause the abnormal development of compounds within the living cells of infested plants; and thereby cause death by "poisoning" (*Chemical News*, vol. 53, p. 255).

Prevention.—(1) Sow only those varieties which are hardy and have been proved to resist the attacks of *P. infestans.* "Besides our potato-bearing *Solanum tuberosum*, there are, amongst the 700 species of *Solanum*, about five which bear tubers—*S. Commersoni*, *Maglia*, *immite*, *verrucosum*, *Jamesi*—of these, *Solanum Commer-*

soni has been cultivated in its native country (Chili) for some time. Experiments have been made in England to introduce some of these species and to cross them with the ordinary potato, in order to obtain a product which might possibly not be susceptible to the potato disease." According to Mr. J. G. Baker, F.R.S., *Solanum Maglia* and *S. Commersoni* would suit the humid climates of Great Britain and Ireland. They are both great disease-resisters.

Nearly all the *old* varieties of cultivated potatoes either fall a ready prey to the attacks of *Peronospora*, or have become so unfruitful as to be scarcely worth planting. The variety known as the "champion" "has lost much of its productiveness." "The 'regent' is worn out; and many of the newer seedlings of that class, although good croppers, are at the mercy of a moist season." Mr. Baker states that *Solanum tuberosum* "in its present tuber-bearing state is in a disorganized, unhealthy condition, a fitting subject for the attacks of fungi and aphides." Other observers say "it is impossible to over-cultivate any plant." In our opinion, this is a mistake, for *over*-manuring with the favourite kainit or potash manures generally has a tendency to favour the development and growth of *Peronospora infestans* and similar fungi (*Chemical News*, vol. 53, p. 255).

Potato-growers should try to produce by crossing, etc., a disease-proof potato. The late Mr. Darwin was greatly interested in Torbitt's experiments "of raising fungus-proof varieties of the potato." He describes Torbitt's method of procedure[1] in the following words: "It consists of rearing a vast number of seedlings from crossfertilized parents, exposing them to infection, ruthlessly destroying all that suffer, saving those which resist best, and repeating the process in successive seminal generations. . . . There is no great improbability in a new variety of potato arising which would resist the fungus completely, or at least much better than any existing variety. With respect to the cross-fertilization of two distinct seedling plants, it has been ascertained that the offspring thus raised inherit much more vigorous constitutions and generally are more prolific than seedlings from self-fertilized parents." (2) Destroy common bittersweet, henbane, and similar plants belonging to the same natural order as the potato, as *Peronospora infestans* also infests these as well as the potato. (3) Burn all infested haulms of the previous potato crops. (4) When the crops are first attacked, a good plan is to remove all infested stems and leaves. (5) "When cut sets are used at planting, the cut surface should perhaps be allowed to heal or dry before planting; or, if this is not convenient, the cut surfaces might be quickly passed over a hot iron." (6) "Potatoes should be stored in perfectly dry, airy places, in positions where *light* is not entirely excluded. Potatoes should never on any account be stored in heaps, or in the damp holes in the ground termed 'pies'" (Smith). (7) The "earthing-up" of potatoes has a tendency to lessen the attacks of *Peronospora infestans*.

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[1] *Life and Letters of Charles Darwin*, vol. iii. p. 348.

Cure.—(1) The author has shown (*Journal Chemical Society*, 1886, p. 119, and *Chemical News*, vol. 53, p. 255) that iron sulphate destroys *P. infestans*, by acting upon the cellulose walls of the mycelium of this fungus, but does not injure the cellulose of the host-plants.[1] A good method of utilizing the sulphate is to prepare a solution containing from 1 to 5 per cent. of *commercial* iron sulphate, and distribute it by means of a Strawsonizer at the rate of two gallons an acre. M. Delacharlonny (*Biedermann's Centralblatt für Agricultur-Chemie*, vol. xviii.) has confirmed the author's investigations, and states that iron sulphate is best applied when the young potato plants have reached the height of a few inches. (2) Top-dress the land (when the plants are a few inches above ground) with ½-cwt. of iron sulphate mixed with 5 to 10 times its weight of sand or dry earth per acre. The above dressing destroys the fungus in the early stages of its life-history. (3) M. Prillieux (*Comptes Rendus*, vol. 107, p. 447) has used a mixture containing copper sulphate (*blue* vitriol) for destroying *Peronospora infestans.* This mixture is made "by dissolving in every 10 gallons of water 6 lbs. of copper sulphate, and then adding 6 lbs. of slaked lime." Dr. J. M. H. Munro (*Bell's Weekly Messenger*, Feb. 4th, 1889) recommends the above mixture to be applied by means of the Strawsonizer or pneumatic distributor.

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[1] The cellulose of parasitic fungi is most probably an isomeric

The Potato Smut (*Tubercinia scabies*) is a fungus which confines itself entirely to the tubers of the potato. It lives between the *cuticle* ("skin") and the *epidermis* of the tuber, often causing a dark-brown envelope over the entire potato. This fungus is to be recognised by the discoloured patches on the cuticle of the tubers. The greenish-brown spores of *Tubercinia scabies* are compound, *i.e.*, they are multi-cellular. The cells unite form-

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modification of the cellulose found in the higher plants. Hence the reason of the difference in the action of iron sulphate in the two cases.

ing a kind of "head" with one or more lacunæ (apertures). The mature spores rupture the "skin" of plant potato and are therefore liberated.

Prevention and Cure.—(1) The seed potatoes should be free from this disease. (2) Steep the seed potatoes in a solution containing from 1 to 5 per cent. of iron sulphate. This will destroy any spores of the potato smut that may be upon them.

Fusisporium solani (*Periola tomentosa*, Fig. 24) is another fungus which attacks potato crops. It makes its appearance chiefly in the autumn, when it is to be seen upon the potatoes growing in the soils of the southern and midland counties. So far, it has confined its attacks to these counties, and has not been discovered in Wales or Scotland. *Fusisporium solani* attacks chiefly the starch granules of the tuber by sending its mycelium amongst the cells, and thereby causes putrefaction. The mycelium, in a few hours, gives rise to conidiophores, being crescent-shaped compound conidia (spores) (Fig. 24 B). The spores, which are divided by three transverse septa, separate when mature (Fig. 24 C), forming four more or less square-ended spores. These subsequently

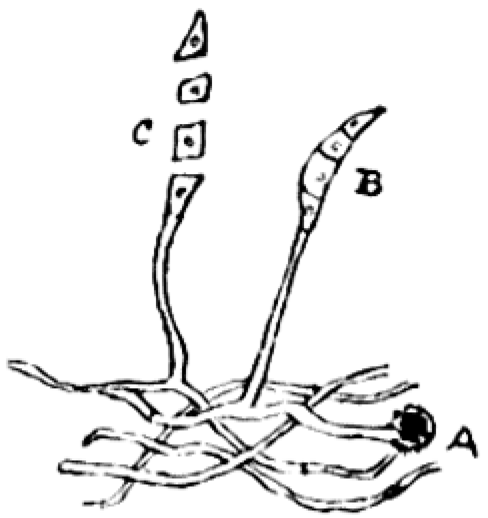

Fig. 24.—Fusisporium solani of Potatoes.
(× 200 diam.)

I have read this book in 1933 on the 22nd July.
O Rall- [redacted]

become round. The spores may germinate immediately or become spinulose (Fig. 24 A) and hibernate for some time. The spores give rise to mycelia when circumstances are favourable for their development and growth.

Prevention.—Burn all infested matter, and plant potatoes free from disease.

The Irish (?) Potato Fungus (*Peziza postuma*, Fig. 25) was first observed in the West of Ireland in 1880, and a description of it appeared in the *Gardeners' Chronicle* for August 20th, 1880. It produces nodular growths upon and within the stems and leaves of the potato plant (Fig. 25 D). Unlike *Peronospora*, this fungus does not cause putrefactive changes to occur within the tissues of the host-plant, but extracts the sap, etc., of the stems and leaves, which finally become dry and

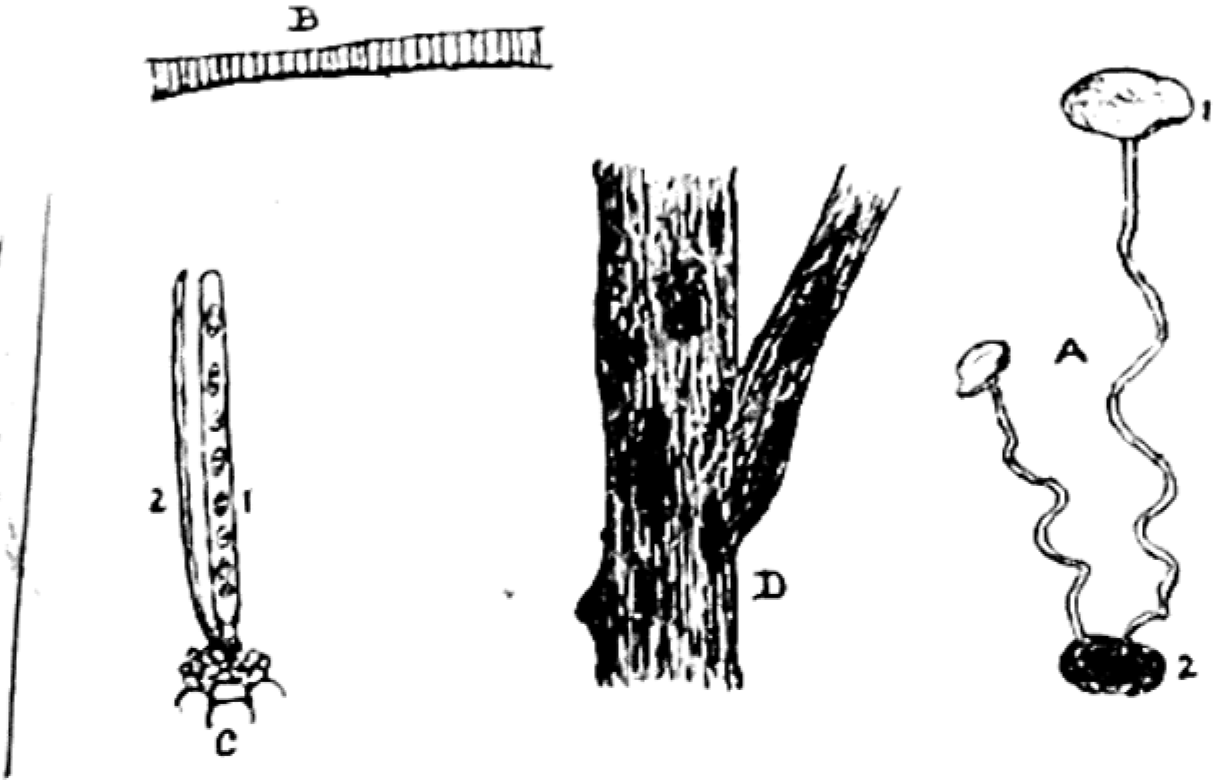

Fig. 25.—PEZIZA POSTUMA (*a potato fungus*).

A. The fungus growing from a Sclerotium (2); at 1 is the pileus or cup-like head (nat. size).
B. Diagram of upper part of pileus, showing the "perpendicular cells."
C. The contents of a "perpendicular cell." (1) Ascus containing spores (sporidia). (2) A paraphysis (× 200).
D. Stem of potato plant with nodular sclerotia (nat. size).

withered. The nodular growths (of a brownish-black colour, although white at first) are composed of a compact, hard mycelium. Each nodule is called a sclerotium, which is capable of hibernating for a longer or shorter time according to circumstances. When one of these bodies grows, it gives rise to a perfect fungus bearing a cup-like head containing spores (Fig. 25 A). The spores after germination reproduce the mycelium, which may either produce spores or become a sclerotium. Fig. 25 A represents a sclerotium giving rise to hyphæ; each hypha bearing a cup-like head (somewhat similar to the pileus or cap of the mushroom) containing millions of spores.

If a transverse section of the hymenium, pileus (?), or cup-like head is examined under the microscope, it is seen to consist of a number of perpendicular cells (Fig. 25 B). Each cell contains an ascus (a kind of "sack") filled with sporidia[1] or spores (Fig. 25 C). The paraphysis[2] (shown in Fig. 25, C 2) is an "organ" developed from the cells of the lower part of the hymenium. At certain times the asci open at the top, and the spores are liberated. It has been estimated that *each* cup-like head contains from two to three million spores.

Prevention.—(1) Artificial manures are better suited than farmyard manure for the cultivation of potatoes. Mr. W. G. Smith, F.L.S., states that "it is bad in practice to place potato sets in immediate contact with decaying vegetable matter and farmyard manure; such materials always contain an immense number of disease germs, both of animal and vegetable origin. The manures used for potatoes should always be old and thoroughly decayed, and it is perhaps best that the cut faces of the sets should be allowed to dry before they are planted." We can thoroughly recommend the following "mixed" manure for the growth of potatoes:—

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[1] Sporidia are spores *free* in an ascus.

[2] Its function is unknown.

			£	s.	d.
Per Acre.	1 cwt.	kainit	0	2	0
	1 ,,	nitrate of soda	0	9	10
	½ ,,	iron sulphate	0	1	3
	2 ,,	mineral superphosphate	0	5	0
			£0	18	1

The ingredients to be thoroughly mixed together, and applied after setting the seed potatoes (See the author's *Treatise on Manures*, or *Manures and their Uses*). (2)

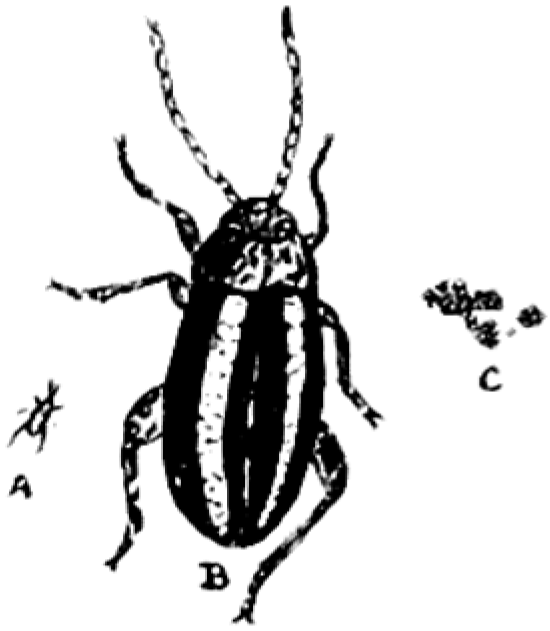

Fig. 26.—TURNIP "FLY" (*Haltica nemorum*).

A. Beetle (nat. size).
B. Beetle (enlarged).
C. Masses of eggs (nat. size).

Burn all infested haulms, as this destroys any hibernating sclerotia, etc.

(7) THE PARASITES OF TURNIPS (*Braşsica rapa*).

The Turnip Fly (*Haltica nemorum*, *Phylletreta nemorum*, or "turnip flea," Fig. 26) belongs to the *Halticidæ*, a family of small *beetles*. They are oval insects, often measuring less than one-twelfth of an inch in length, and have thickened femora (thighs) which enable them to leap almost like fleas. The species under consideration is black with a yellow stripe on each wing-sheath, and is very destructive to turnips. "The eggs are laid upon the underside of the rough leaf from June to September, and hatch in seven or eight days' time." The white larvæ (whose heads are provided with cutting jaws) live between the cuticles of the leaf, and in about six or seven days turn to pupæ, which bury themselves in the ground. In about fourteen days the perfect insects appear. They live through the winter in a torpid state (under bark, clods of earth, and in manure heaps), reviving in the spring. The *spring* is the period of special danger, for these beetles most seriously injure the cotyledons or seed-leaves of the young turnip plant. "Many a farmer has seen a promising braird one evening, but not a vestige of green leaf has been visible on the day following. Unfortunately, the insect is able to travel miles, even against the wind, to wreck a crop of turnips." There are several other species of the *Halticæ* (besides the one described) which feed upon the leaves of the turnip, and often partially or wholly ruin field after field of this crop. The *Halticæ* have several broods in a season.

Prevention.—(1) Destroy charlock, shepherd's purse, and other cruciferous weeds, for the *Halticæ* feed upon these plants as well as upon turnips. (2) "Manure liberally, and obtain a firm and thoroughly fine seed-bed. Beware of clods! Sow the best new seed, and always use the drill instead of broadcasting." (3) Use artificial fertilizers in preference to farmyard manure, unless the latter can be deeply buried. (4) Artificial fertilizers should be deposited along the ridges as soon as the latter are made. They not only give vigour to the plants in their early stages, when the insects commit so much damage, but they ward off the "flies," being objectionable to them.

Cure.—(1) "Roll and lightly harrow after 8 p.m. and before 6 a.m., for this disturbs and weakens the 'fly,' and stimulates the young plant. Sow eight bushels per acre of fresh-slaked lime along the rows just as the plants are appearing." (2) "Dustings of fine ashes or soot are also effectual, but salt must not be used, for it injures the plant and does not hurt the beetle." Dressings should always be applied whilst the dew is on the plants. (3) Mr. W. G. Mount, M.P., has eradicated the turnip fly with either lime or paraffin distributed by means of a Strawsonizer (see Miss Ormerod's *Common Farm Pests*).

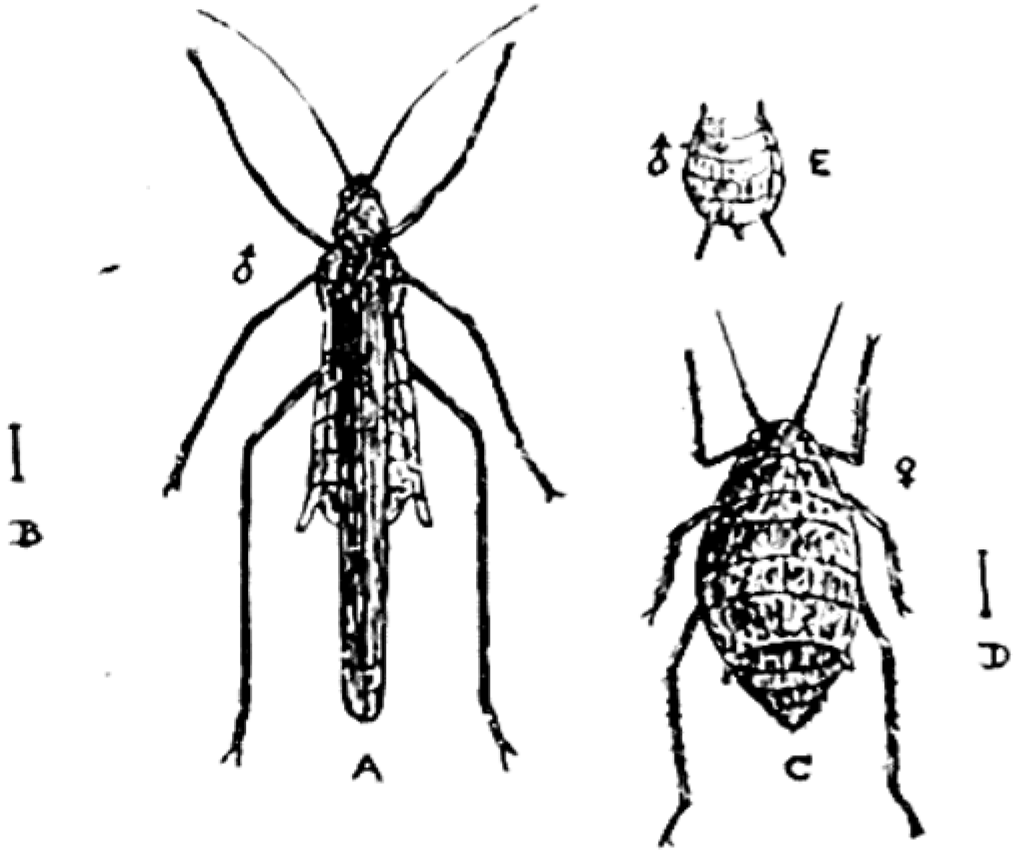

Fig. 27.—Turnip Aphis (*Aphis floris-rapæ*).

A. Male with closed wings (enlarged).
B. Its natural size.
C. Wingless female (enlarged).
D. Its natural size.
E. Flask-shaped abdomen of *Aphis rapæ*.

The Turnip Aphis or Green Fly (*Aphis floris-rapæ* and *Aphis rapæ*, Fig. 27) is allied to the bean aphis already described. The *Aphidæ*, or plant-lice, are an excessively injurious family of *Homopterous* insects. Every farmer, every rose cultivator, every hop-grower has too great reason to be well acquainted with these destructive pests. The species are very numerous, almost every plant having its own peculiar parasite; they attack the leaves, stems, shoots, and even the roots of plants, piercing with their sharp proboscis the cuticles and sucking the juices. *Aphis rapæ* is chiefly found on the under surfaces of turnip leaves. The wingless female (viviparous) is green, but becomes a yellowish-red colour later in the season. The head and thorax of the winged female are black, whilst the abdomen and wings are of a yellow colour. The posterior part of the abdomen of this species is flask-shaped (Fig. 27 E). According to Curtis, the variety known as *Aphis floris-rapæ* (Fig. 27 A and C) is found on the flower-stalks. *Aphis rapæ* "multiplies with amazing rapidity under favourable atmospheric conditions."

The great enemies of the *Aphidæ* are the so-called "lady-birds"—small beetles belonging to the *Coccinellidæ*. The French call these insects "Bête de la Vierge" and "Vache à Dieu." The Germans call them "Marienkäfer," "Marienkuh," and "Gotteslämmchen." The majority of these insects are undoubtedly the friends of the farmer, and their presence upon all cultivated plants is most beneficial. The "common," or seven-spotted lady-bird (*Coccinella septempunctata*), and the two-spotted lady-bird (*C. bipunctata*) are common species. "They lay their eggs in small patches in the midst of the *Aphides* which are destined to furnish nourishment to the larvæ."

Prevention and Cure.—(1) "Nearly all the remedies proposed for the extermination of *Aphis rapæ* consist of water containing some poisonous infusion, such as tobacco, quassia, ammonia, etc. On a *large scale* the application is costly; and although it may pay for a crop of hops, it has hitherto been impracticable for roots." (2) "When the turnips are attacked near maturity, the folding of sheep destroys the insects, and may prevent their reappearance in the following season."

The Turnip Gall Weevil (*Ceutorhynchus sulcicollis*, Fig. 28) belongs to a group of beetles called the *Rhynchophora*, whose snouts, as a rule, are very long. The antennæ are placed on each side (of snout), "elbowed" or angulated in the middle and clubbed at the extremity. The female turnip gall weevil punctures the "roots," and deposits an egg in the wound. Within this domicile the yellowish-coloured larva or maggot lives, feeds, and attains its maturity. This beetle (Fig 28 C) is most injurious to

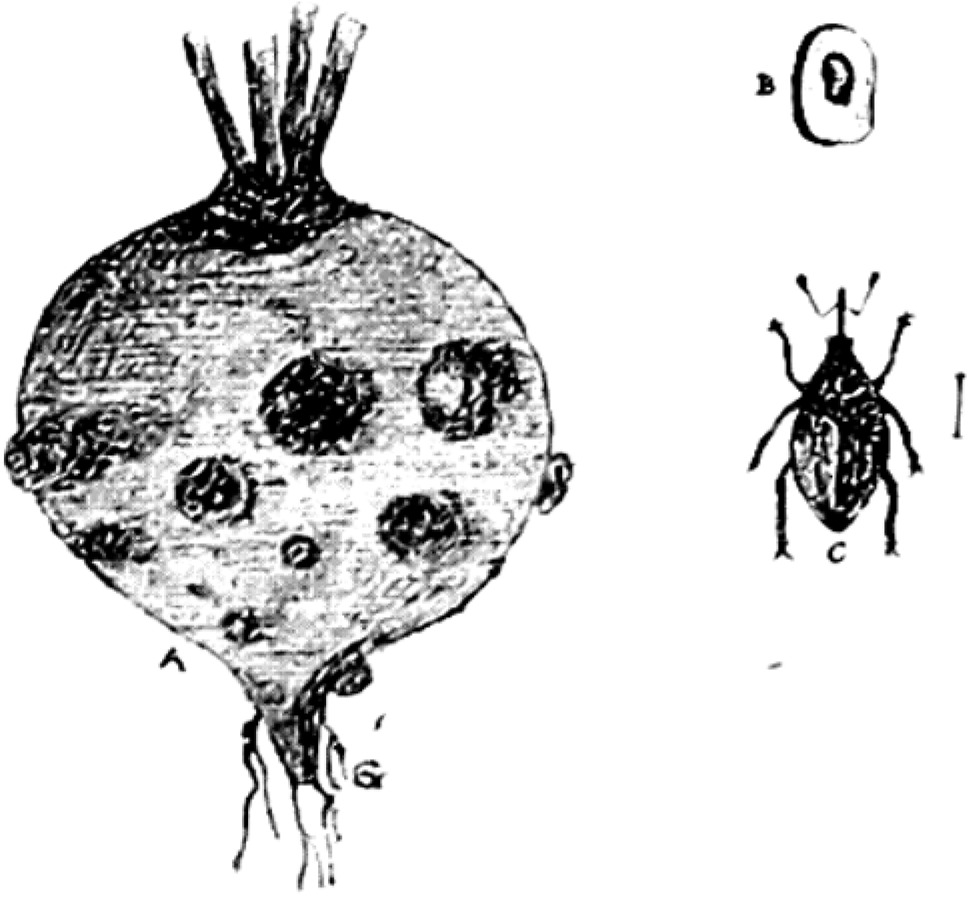

Fig. 28.—Turnip Gall Weevil (*Ceutorhynchus sulcicollis*).

A. Gall-like excrescences on turnip-bulbs.
B. A gall with grub inside (nat. size).
C. Turnip Gall Weevil (enlarged).

swedes and turnips. The larvæ cause gall-like excrescences (Fig. 28 A) to grow upon the surfaces of turnip "roots." When the larvæ have attained maturity, they are provided with powerful jaws, which are used for gnawing a way out of their temporary abode. The larvæ turn to pupæ in the soil, where they remain about twenty-eight days, enclosed in "earth-cases." The perfect insect is of a blackish hue, and the elytra are marked with a number of stripes and dots.

This weevil *greatly reduces the quality* of the roots, as the following analyses show :—

ANALYSIS OF TURNIP ROOTS.[1]

		Uninjured Roots.	Injured Roots.
Dried solid matter.	Albuminoïds (flesh formers) . .	9·86	7·10
	Soluble carbohydrates and fat (fat producers)	71·90	62·02
	Woody fibre	11·24	23·25
	Ash	7·00	7·63

The above table shows that the injured roots contain smaller percentages of albuminoïds and soluble carbohydrates than the uninjured roots.

It is stated that, in both the larval and pupal stages, this weevil is capable of enduring a temperature many degrees below the freezing-point of water.

Prevention.—(1) "Regular rotation of crops, generous and clean cultivation, and the free use of lime or gas-lime, will prevent this weevil from doing much harm." (2) "Galled portions of roots which are left by sheep should be burned."

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[1] Dr. A. B. Griffiths' analyses.

The Harvest Bug (*Tetranychus autumnalis*) belongs to the *Arachnoidea*, and for several reasons the members of this class are looked upon as *modified* insects. The so-called "harvest bug" is a spinning mite, and on the authority of M. Megnin (*L'Insectologie Agricole*) possibly injures the *leaves* of turnips as well as those of grass and corn crops.

According to Curtis, another arachnoid (*Trombidium trigonum*) injures the spikes of corn, especially in France.

The Turnip Leaf Miners (*Drosophila flava* and *Phytomyza nigricornis*) are the larvæ of two dipterous flies which feed upon the parenchyma (soft parts) of turnip leaves. *D. flava* is about one-tenth of an inch long, of a yellow colour. The larvæ of this two-winged fly are of a green colour, and live beneath the cuticle on the *upper* side of the leaves. *P. nigricornis* is the same size as the "yellow leaf miner," but has a black body and slate-coloured wings. The larvæ burrow beneath the cuticle on the *under* side of turnip leaves, and there feed upon the soft parts. The pupæ of both insects are brown in colour, and, as a rule, the larvæ turn to the pupal stage within the leaves.

Prevention.—Burn all infested leaves.

The Turnip Moths (*Plusia gamma*, *Cerostoma xylostella*, *Noctua* [*Agrotis*] *exclamationis*, and *Noctua* [*Agrotis*] *segetum*) are four in number, and their methods of attack are somewhat dissimilar. (*α*) The Silver Y Moth (*Plusia gamma*) has already been described. (*β*) The Diamond-back Moth (*C. xylostella*) "seldom does much damage." The green-coloured larvæ feed on the foliage of turnips and swedes. They are about half an inch long, and taper towards both ends. When mature, the caterpillars spin light cocoons between the veins of the leaves

—the latter having been stripped of the intermediate soft tissues. Within the cocoons the caterpillars turn to pupæ, which are of a grey colour with black markings. The pupæ give rise to perfect insects in about fourteen days. The moth is somewhat similar in appearance to the ordinary clothes-moth. Along the anterior edge, the fore wings are brown, while the posterior edge is white. The hind wings are deeply fringed. (γ) The larvæ of the Heart and Dart Moth (*N. exclamationis*) also feed on the foliage of turnip crops. They attack the plants during the night, while in the daytime they hide beneath stones, clods of earth, etc. The larvæ of this moth are about 1½ inch long, of a pale violet colour, with a brown head. When fully grown they make earth-cells, and there turn to pupæ. The latter are of a reddish-brown colour, and hibernate (in their cells) until the following season. The moth is of an ochre colour, with a black spot situated posteriorly to the head. The anterior wings of both the male and female are brown, with darker coloured nervures. The posterior wings of the male are white, while those of the female are brown. (δ) The larvæ of the Turnip Moth (*N. segetum*) feed on turnips and other roots by gnawing their way into the "roots." They also feed on the leaves of the turnip plants. These larvæ (which are nocturnal in their habits) are about one inch long, almost hairless, and feed not only during the summer and autumn, but also in the winter if circumstances are favourable. If not, they pass the winter in earth-made cells. In the following spring they turn to brown-coloured pupæ in the ground, where they remain for twenty-eight days, changing in that time to moths. The male moth has grey-coloured fore and white hind wings. The colour of the thorax and abdomen is also grey. The fore wings, thorax, and abdomen of the female are brown, while the hind wings are white.

Prevention.—(1) "Generous culture, clean boundaries, strong-growing seeds will keep down the 'turnip moths.'" (2) The rook, partridge, jackdaw, raven, chiff-chaff, magpie, blue-tit, redstart, and crow, all destroy the larvæ of these and similar farm pests.

Cure.—Gas-lime, tobacco-water, lime, soot, and hand-picking are remedies not difficult to apply; although they add to the cost of cultivating turnip crops.

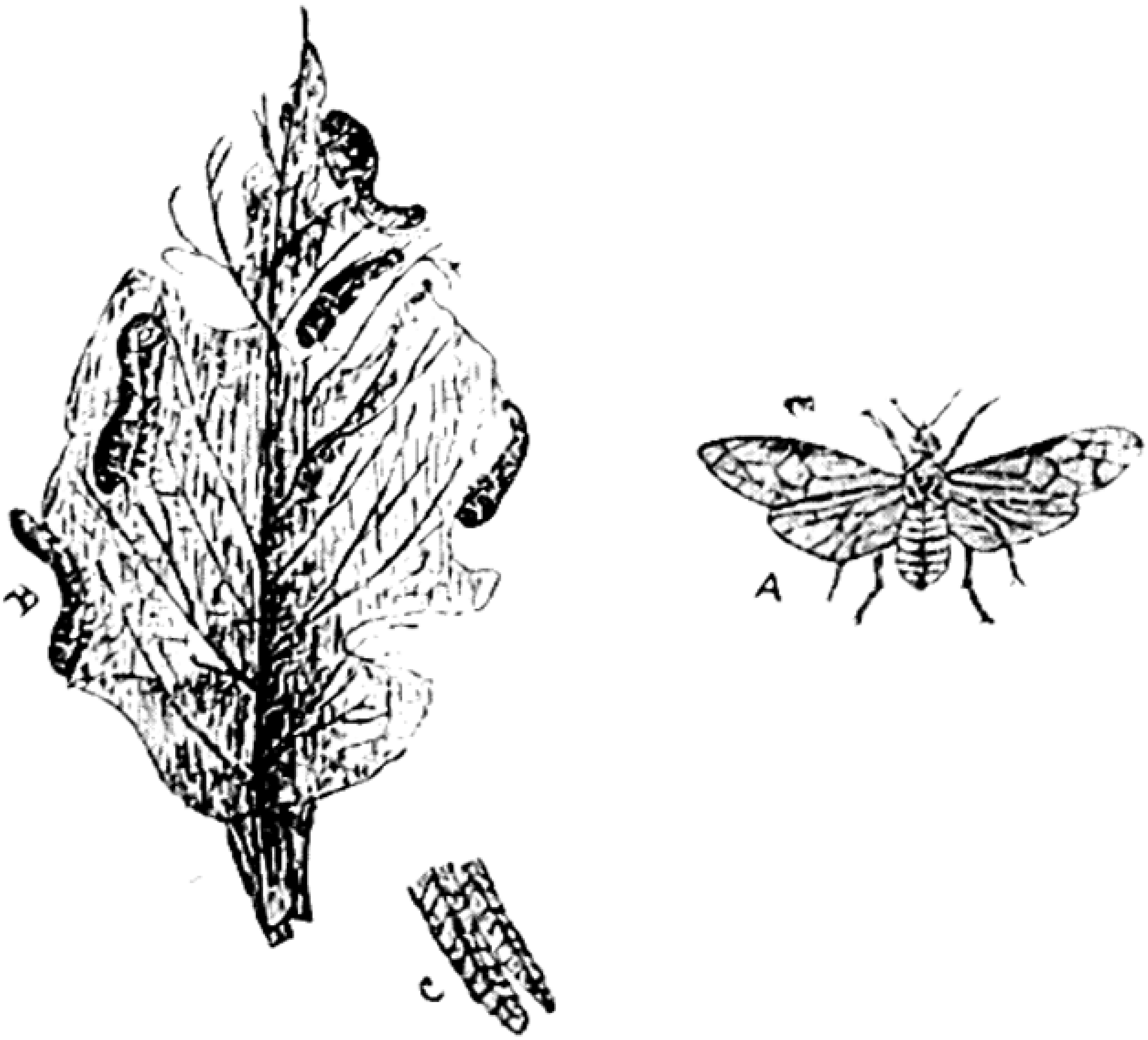

Fig. 29.—Turnip Saw-Fly (*Athalia spinarum*).

A. Turnip Saw-Fly (enlarged slightly).
B. Larvæ feeding upon turnip leaf.
C. A portion of the saw-like organ.

The Turnip Saw-Fly (*Athalia spinarum*, Fig. 29) belongs to a family of insects distinguished by the peculiar construction of the ovipositor,[1] which has procured for them the name of "saw-flies." This organ (Fig. 29 C), which is to be found on the posterior-ventral side of the perfect insect, is composed of a pair of broad, serrated plates, the analogues of the inferior bristles of the bee's sting. By the agency of this curious organ, the female cuts numerous minute slits in the leaves of the turnip plants, in each of which she lays an egg. It is said that each female lays from two to three hundred eggs during a season. The eggs are hatched in from four to ten days. The larvæ (Fig. 29 B) (called "niggers," "blacks," "black caterpillars," etc.) feed upon the leaves of turnips, which they reduce to mere skeletons of fibres, and sometimes cause the complete destruction of the crops over a considerable extent of country. The young larvæ are of a green colour, but ultimately turn black. "The larva of *A. spinarum* is large at the head tapering to the posterior, and possesses a remarkable structure in its feet, some of which are hooked, and others act as suckers." In about three weeks after birth these caterpillars retire to the ground, where they spin cocoons in which they turn to the pupal stage. During the early summer the pupæ are transformed into perfect insects in about twenty-one days, but if late in the season the larvæ remain in the cocoons throughout the winter, turning to pupæ in the following spring. There are several broods in a season. The perfect insect (Fig. 29 A) is a pretty black and yellow fly, with short antennæ, and is common in the fields during the summer. According to the late Mr. Curtis, these flies come over from the North of Europe, but are probably bred in small numbers annually in this country.

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[1] An organ which aids in the laying of eggs.

Prevention.—(1) As "the caterpillars are found in swarms, drawing bushes over the plants disturbs and distributes them advantageously." Then throw lime or lime and soot over the plants—this "will do something towards protection." (2) "A thick sowing of good seed will generally be found to have insured sufficient plants for a crop."

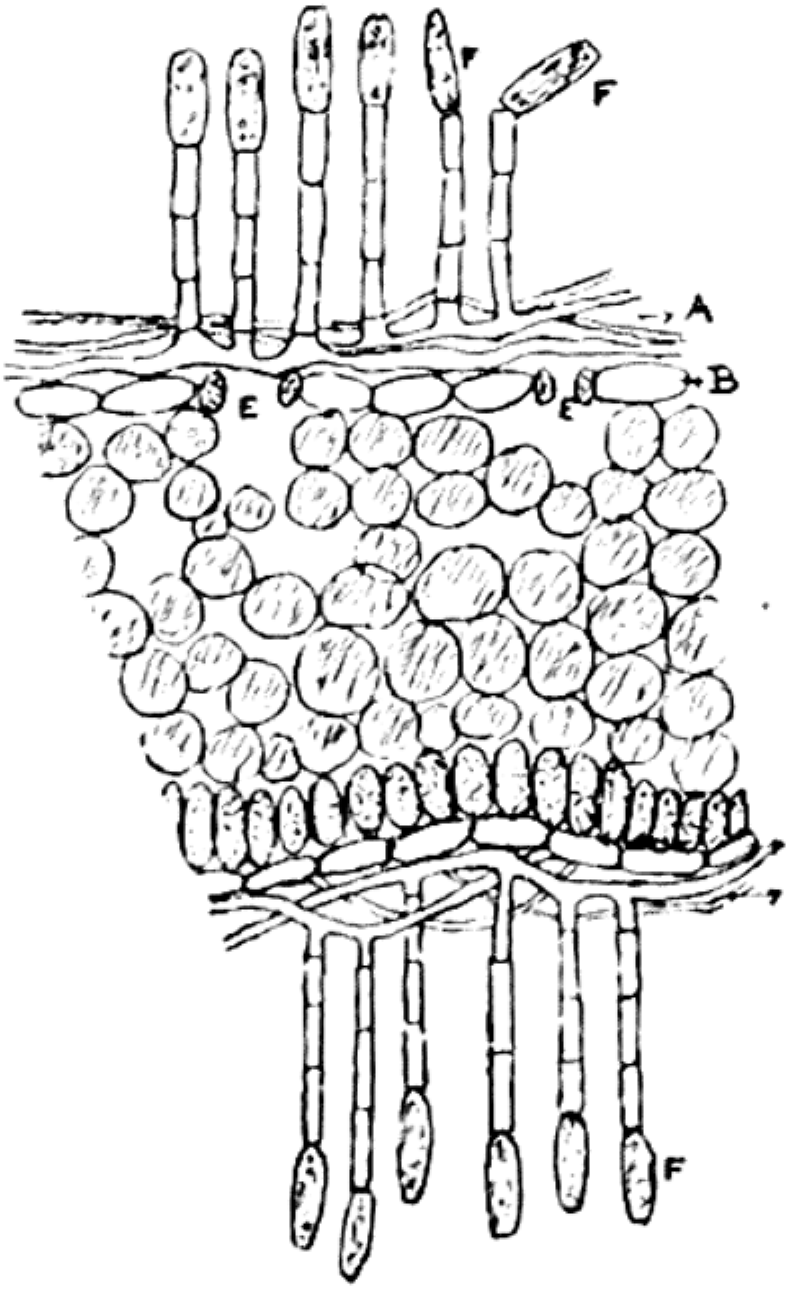

Fig. 30.—Surface Fungus of Turnips (*Oidium Balsamii*).
B C. Lower and upper surfaces respectively of a turnip leaf.
A D. Mycelia (spawn) on both surfaces.
E. Stomata. F. Conidia (spores). × 105.

(3) Watering the plants (by means of a water-cart) is beneficial to the crops and prejudicial to the insects.

The Surface Mould of Turnips (*Oidium Balsamii*, Fig. 30) is a fungus which attacks turnips (especially swedes) chiefly in the South of England. So far, it has not been found in Scotland; most probably because it requires a higher mean temperature than occurs in North Britain. This mildew or mould *does not* enter the tissues of the host-plant, but lives upon the two external surfaces of the leaves. When a crop of turnips is attacked by *Oidium Balsamii*, the foliage appears white on both sides. The mycelium (Fig. 30 A and D) spreads over the cuticle of the leaves; and gives rise to perpendicular conidiophores bearing elongated, square-ended conidia or spores (Fig. 30 F). It has been estimated that there are more than 10,000 spores on every square inch of the infested leaves. The conidia of this fungus germinate readily, and give rise to mycelia.

As the fungus covers both sides of the turnip leaves, it greatly interferes with the processes of assimilation and transpiration; and thereby prevents further growth. This causes a low yield of roots. The further life-history of this fungus is unknown.

Cure.—Possibly a solution of iron sulphate or copper sulphate would destroy this fungus (see the "cures" for the potato disease).

The Turnip Mould (*Peronospora parasitica*), which belongs to the same genus as the potato-disease fungus, will be described under the head of "The Parasites of Cabbages," as it attacks these plants as well as turnips.

Finger-and-Toe, Anbury, or Clubbing of Turnips (*Plasmodiophora brassicæ*, Fig. 31). Every farmer knows that turnip and other root crops are liable to degenerate through the abnormal growth of nodules or knobs[1] upon the tubers, roots, and rootlets. Turnips so affected soon rot, and have a fœtid odour, so that they are not only useless themselves, but communicate the disease more or less to the whole crop. The cause of "clubbing" was proved by M. Woronin in 1876 to be due to a slime fungus belonging to the *Myxomycetes*. "The *Myxomycetes* are especially remarkable, from the fact that they do not form cells, cell-walls, 'tissues' or mycelium, during the period of vegetation; but their protoplasm remains during that time free, and collected into small masses of various and changeable forms. At a certain definite advanced period of growth the vital material of a *Myxomycete* breaks up into small portions, and these portions at length surround themselves with a cell-wall, and become either fruits, sporangia, or spores; and in this condition the fungus remains at rest during a certain definite period." This is essentially different from the life-history of *Peronospora infestans* or any other fungus previously described.

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[1] See the author's book: *Manures and their Uses*, p. 40.

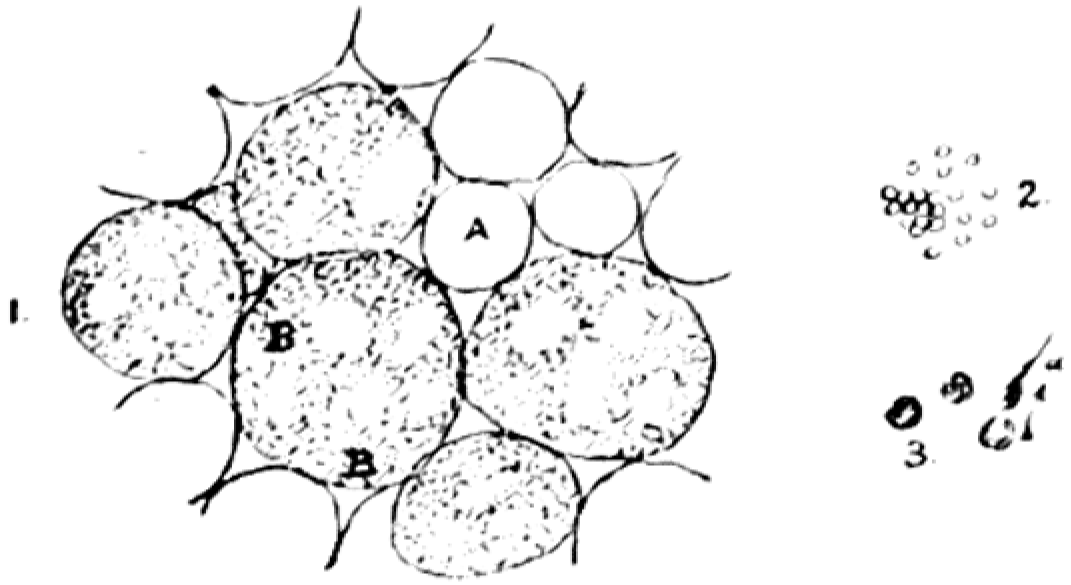

Fig. 31.—"FINGER-AND-TOE" OF TURNIPS (*Plasmodiophora brassicæ*).

1. Transverse section of turnip root, showing the "plasma" (B) of the fungus. A. Normal size of cell. B. Cell distended by fungus (× 100).
2. Spores, produced from plasma (× 195).
3. Spores giving rise to zoöspores (a) (× 490).

The spores of the club-root fungus generally commence the attack in turnip seedlings; by entering the rootlets with water in an attenuated form. As growth proceeds, the turnip plants become diseased, the foliage droops, and the roots are stunted in growth. If during the summer a thin transverse section of one of the nodular out-growths is examined under the microscope, a large number of cells will be found filled, or nearly filled, with the slime or plasma of this fungus (Fig. 31, 1). This slime greatly distends the cells of the turnip, and thereby causes the nodular outgrowths upon the roots, known as " clubbing." There are no hyphæ.

As the fungus increases in size, the nodules also increase. In the autumn the slime or plasma breaks up into numberless small spores (Fig. 31, 2), which are surrounded by cell-walls. The spores rest during the winter in the turnip roots. In the following spring (if circumstances are favourable) the spores germinate, when little jelly-like masses exude from them (Fig. 31, 3). Each little mass is called a zoöspore, and is provided with a cilium (a " vibrating tail "), which enables it to move over moist surfaces. The zoöspores of *P. brassicæ* are always changing their shapes—hence they are somewhat similar to certain low forms (*Amœbæ*) belonging to the animal kingdom. The zoöspores of the club-root fungus (like certain of the *Monera* [1]) quickly coalesce and form what is known as a plasmodium—hence the generic name of the fungus. If infested and rotten turnip roots have been previously thrown on manure heaps, and the manure then distributed over the land, the plasmodia are liberated by rain or the moisture of the soil, and are then ready to commence the work of destruction in any young turnip, cabbage, or other cruciferous crop near at hand.

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[1] See Haëckel's *Studien über Moneren.*

The following analyses (by the author) show the changes which occur within turnip roots during the *early* stages of the growth of *Plasmodiophora brassicæ* :—

Albuminoïds in	healthy roots	9·92	per cent.
,,	diseased ,, (*minus* nodules)	5·23	,,
,,	nodules (with fungi)	18·61	,,

The above analyses show that the growth of the fungus lessens the percentages of albuminoïds or nitrogenous substances in the roots. As *Plasmodiophora* (like all fungi) cannot "manufacture" albumin and requires it—it extracts this life-giving substance from the living cells of the host-plant.

Prevention.—(1) Do not allow the cruciferous weeds, more than is possible, to choke the hedge-sides of the fields and ditches under cultivation. (2) As the spores of this fungus retain their vitality for several years under favourable circumstances, when land has borne an infested crop, the best thing to do is to remove decaying roots, stumps, etc., and burn them. (3) Rotation of crops, *i.e.*, allow two or three years to elapse before again sowing cabbages, turnips, or other root crops. (4) Whenever possible, avoid working the land in a wet condition. (5) The selection of good seed[1] and the most approved methods of culture are means of preventing this disease.

Cure.—After clearing the land, give it a good dressing of gas-lime or lime and soot.

This chapter surveys the life-histories of parasites which infest *root* crops. Some belong to the animal, others to the vegetable kingdom. Every cultivated plant has its own foes; but whether we look upon them as enemies or not, they have all come into the world for the same object as the rest of animated nature—namely, to live, reproduce, and die—so the world goes on! They are, therefore, part and parcel of the organic world and not isolated from it. In the words of Carlyle:[1] "Detached, separated! I say there is no such separation: nothing hitherto was ever stranded, cast aside; but all, were it only a withered leaf, works together with all; is borne forward on the bottomless, shoreless flood of Action, and lives through perpetual metamorphoses. . . . Rightly viewed, no meanest object is insignificant; all objects are as windows, through which the philosophic eye looks into Infinitude itself."

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[1] Turnip seeds have often been adulterated with charlock, "Indian rape," and other seeds of the *Brassicaceæ*.

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[1] *Sartor Resartus*, chap. xi.

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CHAPTER IV.

THE DISEASES OF GRAMINEOUS CROPS.

(1) THE PARASITES OF BARLEY (*Hordeum distichum*).

The Grain Aphis (*Aphis granaria*, *Siphonophora granaria*) is about the same size and somewhat like the bean aphis already described. The abdomen of the winged female is green, the thorax and head brown, and the wings green with brown veins. The wingless female (viviparous) has a greenish coloured body with brown antennæ, and the legs are devoid of hairs. Both the wingless and winged females have red eyes. The pupæ are of a chrome-yellow colour and the larvæ green. *A. granaria* injures oats, rye, and wheat, as well as barley, by sucking the juices from the young stems and leaves of these crops. Later in the season, this insect attacks the ears of corn (when the grain is green), and often causes considerable damage. On the authority of Mr. Walker, *Aphis granaria* passes the winter on "certain grasses."

Prevention.—(1) The Grain Aphis has two parasitic foes, namely—*Ephedrus plagiator* and *Aphidius avenæ*—two flies (about the same size as *Aphis granaria*) belonging to the *Ichneumonidæ.* These flies pierce the bodies of the aphides with their sharp ovipositors and lay an egg in each newly-made cavity. The eggs soon turn to larvæ which feed on the aphides. These parasitic flies remain within the bodies of the aphides during the pupal stage, and, when they turn to perfect insects, they eat their way out of the now dried and puffed-out skins of the aphides. (2) Another enemy of this and other aphides is the blue-tit (*Parus cæruleus*). This little bird and the titmice generally are without doubt the friends of the farmer. Mr. W. Swaysland (*Familiar Wild Birds*) says: "The number of obnoxious pests destroyed in one day by a *blue-tit* must be very considerable, and it is to be regretted that due importance is so seldom attached to this fact by gardeners and other individuals who wage war against it, merely regarding it as a nuisance and a depredator." (3) Good cultivation and a liberal supply of manure (artificial as well as natural) are means of preventing the attacks of this pest.

Cure.—Dressings of lime, soot, or soot and lime, whilst the crop is young, are means of destroying *Aphis granaria.*

The Ribbon-footed Corn Fly (*Chlorops tæniopus*, Fig. 32)[1] attacks barley and wheat crops, but more particularly the former. "Plants affected by *Chlorops* are easily detected. Generally, the ears are not free as healthy ears, but are enwrapped still in the sheathing leaves. Little yellow maggots may be found near the nascent ears, sucking out the juices of the plant. When these injured ears get out of their sheath, or are stripped of their sheath when the plants are ripening, a destructive furrow is seen from the base of the ear to the internode (Fig. 32 D). In this furrow the larva changes to a pupa." Affected plants are shorter than healthy ones, "their stems are stouter and the joints are frequently swollen, or 'gouty' in fact."

The fly (Fig. 32 A) is of a yellow colour with brown markings on the dorsal side of the thorax and abdomen. The six legs are yellow with black tarsi (feet). The perfect insect makes its appearance usually in May. The female lays eggs (white) near the base of the sheathing leaves of barley plants. The eggs are hatched in four or five days, when the yellow, legless maggots pierce a way into the young ears of corn, and feed there by extracting the sap, etc., of the host-plants. "The larva always makes a furrow from the base of the ear to the first joint or knot of the stem. In this furrow the change from the larval to the pupal stage takes place." According to Dr. Taschenberg[1] the larvæ of *Chlorops* hibernate

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[1] "Gout fly," "Haulm fly," etc.

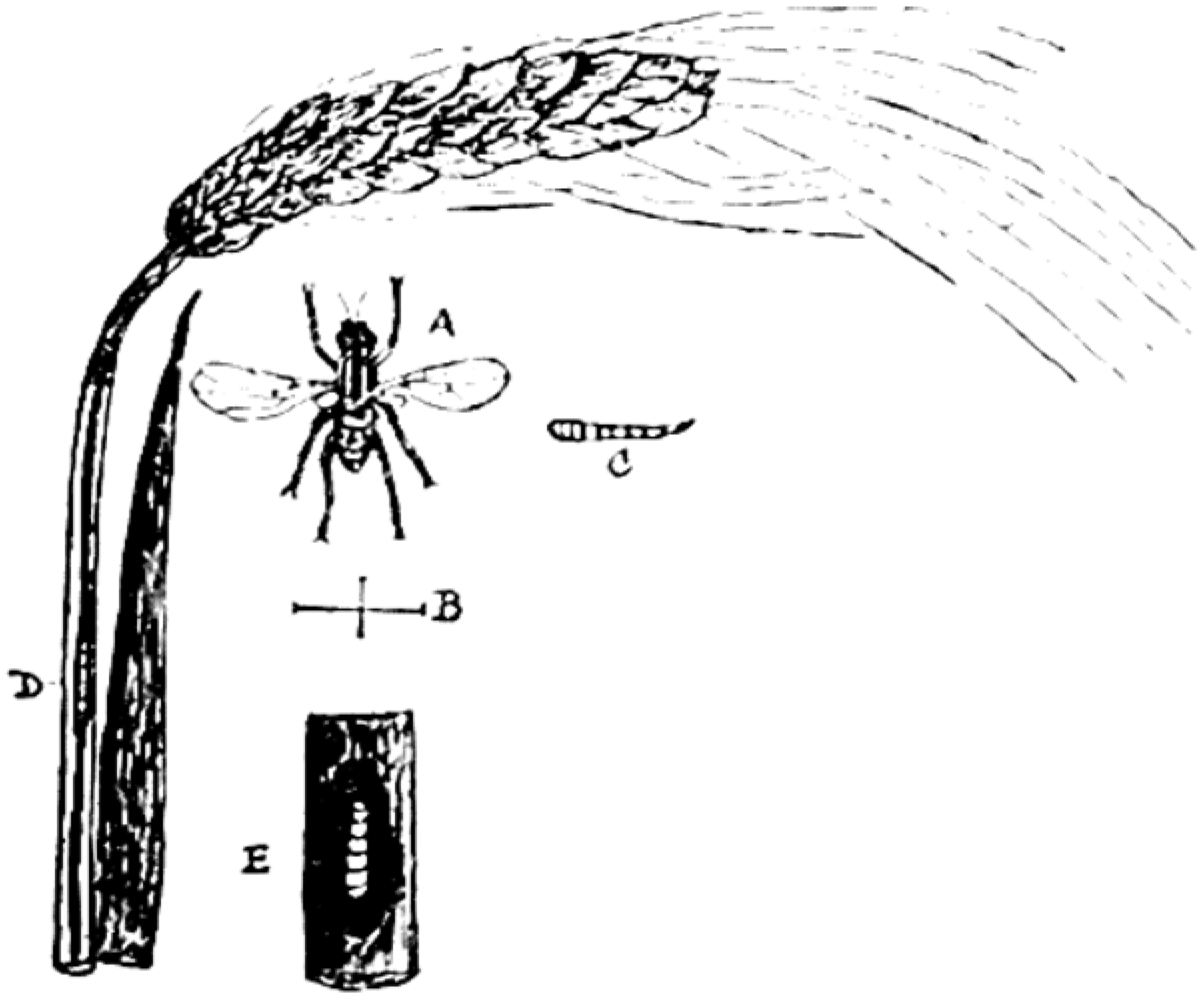

Fig. 32.—RIBBON-FOOTED CORN FLY (*Chlorops tæniopus*).

A. The fly (enlarged).
B. Its natural size.
C. Larva (nat. size).
D. Infested stem.
E. D. enlarged.

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[1] See his *Praktische Insekten-Kunde* and his various memoirs.

in the leaves and stems of grasses. The pupæ of this insect are of an ochre colour. *Chlorops* has several foes belonging to the *Insecta;* the most important of which are *Pteromalus micans* and *Cœlinius niger*—two flies which lay eggs within the bodies of the maggots of *Chlorops tæniopus.* The larvæ produced from these eggs feed and live upon the maggots of *Chlorops*, reducing them to mere empty skins.

It has been estimated that this fly caused a loss of from 3 to 14 bushels of corn per acre (Whitehead's "Reports").

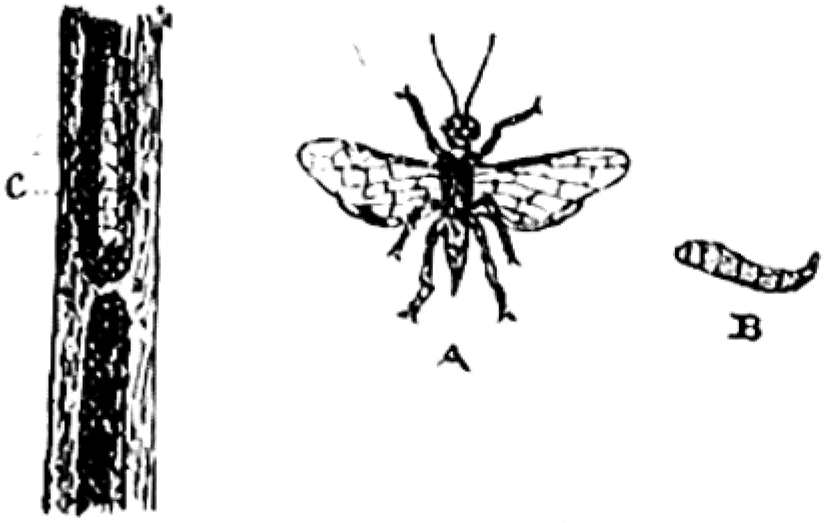

Fig. 33.—The Corn Saw-Fly (*Cephus pygmæus*).
A. The fly (nat. size).
B. Larva (nat. size).
C. Infested stem (enlarged).

Prevention.—(1) Grasses, etc., infested with *Chlorops* should be eaten by sheep. (2) After thrashing infested barley or wheat, the chaff, etc., should be burnt. (3) Pulling up all stunted and infested plants has a tendency to greatly reduce the attacks of this pest. (4) Promote healthy and vigorous growth by the judicious use of *soluble* manures; for barley is a "shallow feeder" (*i.e.*, it obtains nourishment from the *surface* soil), and requires easily assimilable plant-foods.

The Corn Saw-Fly (*Cephus pygmæus*, Fig. 33) belongs to the *Hymenoptera*, and attacks barley and other corn crops. The female pierces, by means of its saw-like ovipositor, a hole in the young corn stem, and lays an egg therein. The white larva or maggot (Fig. 33 B and C), which is hatched in about ten days, feeds on the sap and soft tissues in the interior of the stems of the barley or wheat plants, causing great injury. The larvæ are provided with powerful jaws, capable of cutting furrows in the stem of the host-plant. The larvæ ultimately spin silken cocoons, in which they hibernate in the stems of the stubble. In the following spring they turn to pupæ, making their appearance as perfect insects about May. The perfect insect has four wings which are iridescent. The body is black with yellow markings. "From ten to a dozen eggs are laid by each female, and are deposited singly in the stems of the corn plants not far from where the ears are forming, whose situation is divined with wonderful instinct."

Prevention. — (1) Plough in deeply all infested stubbles. (2) "Scarifying, or cultivating, the land and burning the stubble harrowed together would also be useful, though not so sure as ploughing it in."

Cure.—All infested lands, after ploughing in the stubble, should be treated with quicklime, salt, or gas-lime, for these substances destroy the larvæ of this farm pest.

The Fusisporium of Barley (*Fusisporium hordei*, Fig. 34) attacks the ears of barley. The infested grains of barley become covered with orange or scarlet-coloured mycelium and conidia of this fungoid growth. The fungus is allied to another species of the same genus, viz., *F. solani* (already described). The crescent-shaped spores ultimately separate and become globular conidia, which rest for a short time, but finally give rise to new mycelia. The fungus obtains nourishment from the entire grain (embryo, cotyledon, and husk),—but particularly the embryo or germ,—and thereby destroys the germinating power of the grain (either for seed or for malting purposes). It has been stated that the conidia of this fungus, when introduced into beer-wort (previously sterilized), give rise to a slow alcoholic fermentation, as well as producing a badly flavoured beer.[1]

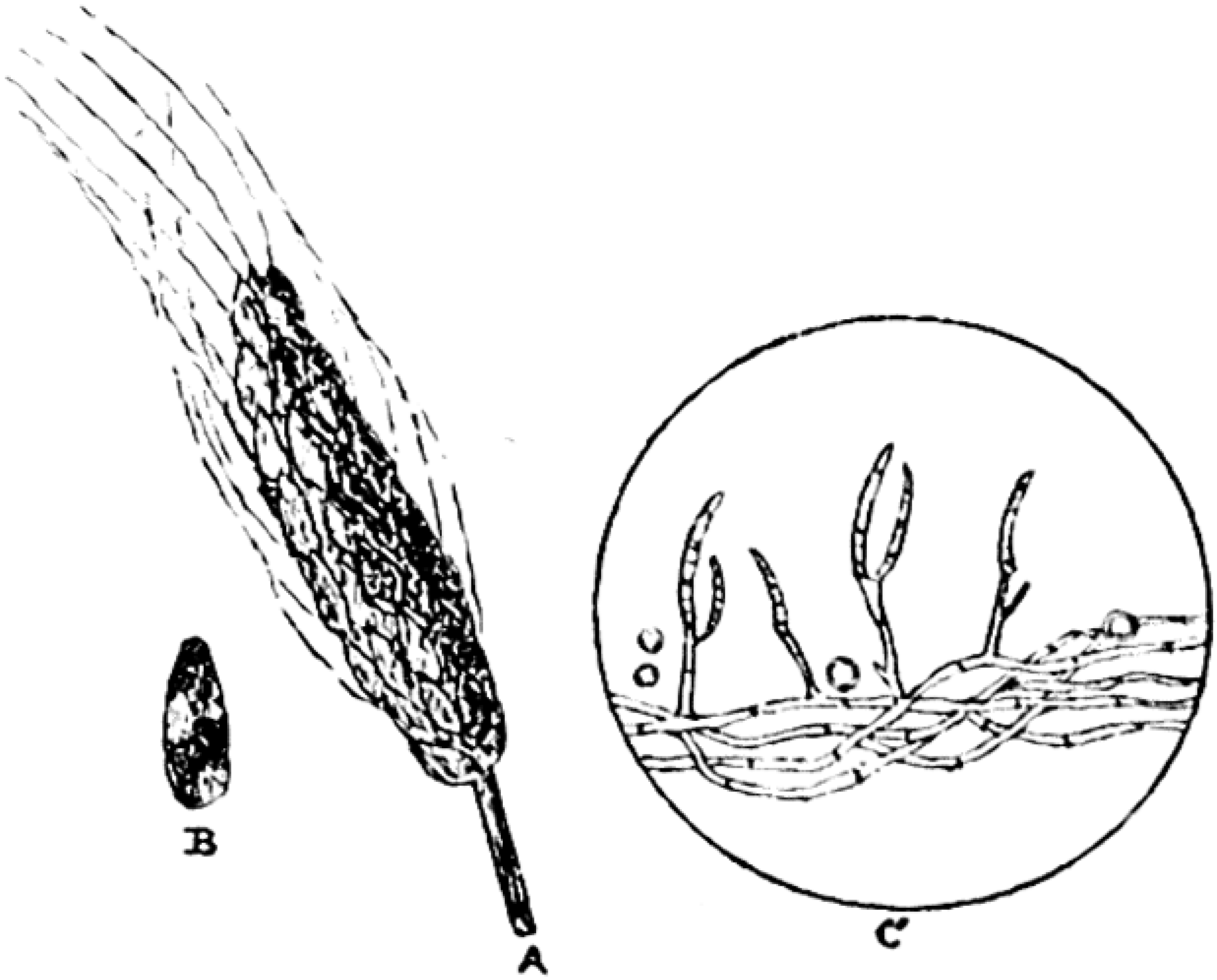

Fig. 34.—The Fusisporium of Barley (*Fusisporium hordei*).

A. An ear of barley infested with the fungus.
B. Barleycorn (infested).
C. The fungus. × 320 diameters.

The name *Fusisporium hordei* was given to this fungus by Mr. W. G. Smith, F.L.S., who, with other fungologists, investigated its life-history.

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[1] The author has shown that most of the so-called "false beer ferments" are destroyed by the action of a solution of salicylic acid (see *Proceedings Royal Society of Edinburgh*, vol. xiii. p. 527; *The Brewers' Guardian*, vol. xvi. p. 21; and *Journ. Chem. Soc.*, 1886, p. 386).

Prevention.—Sow only new and sound barley.

Cure.—(1) Steep the seed, for two or three hours before sowing, in a solution of iron sulphate (1 to 2 per cent. solution). (2) Copper sulphate is recommended for "pickling" the seeds of various cereals before drilling; but this substance often destroys the germinating power of seeds (*vide Biedermann's Centralblatt für Agricultur-Chemie*, 1886, p. 766).

The Smut of Barley (*Ustilago carbo*) and other cereals will be described under "The Parasites of Oats."

(2) THE PARASITES OF BUCKWHEAT (*Polygonum fagopyrum*).[1]

According to Alphonse De Candolle, buckwheat is probably an Asiatic plant. "In China the seed is used for making bread, and in Europe it is employed for various culinary purposes." In England it is principally sown to produce a covert and food for game. On the Continent (and also to a minor extent in England) buckwheat is used as a green manure. The gaseous products of its decomposition destroy various injurious insects.

The Buckwheat Eelworm (*Tylenchus Havensteinii*) belongs to the same genus as the clover eelworm, already described. It is a nematoid, and measures 1·43 mm. × 0·0301 mm.[2] These thread-worms attack the roots and stems of the host-plant.

Cure.—Drs. Kühn and Oehmichen recommend liberal manuring, especially with kainit.

The Buckwheat Beetle (*Phyllopertha horticola*) is a small cockchafer belonging to the family *Rutelidæ*. This beetle measures less than half an inch in length, and is a bluish-green colour, with reddish-brown wing-cases (elytra). The larvæ feed on the flowers of buckwheat, causing considerable damage to the grain. The ravages of this beetle are chiefly confined to Germany and other parts of the Continent. For further information the reader is referred to Dr. Calwer's *Käferbuch*, or Taschenberg's *Praktische Insekten-kunde.*

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[1] Buckwheat belongs to the *Polygonaceæ* (dock and sorrel order). It is not a gramineous crop, although described under that heading.

[2] 1 millimetre (mm.) = 0·03937 inch.

(3) THE PARASITES OF GRASSES.

The Grain Aphis (*Aphis granaria*) has already been described.

The Crane Fly, or Daddy Long-legs (*Tipula oleracea*), belongs to the *Tipulidæ*. The proboscis of the crane fly is very short, terminating by a pair of fleshy lips which enclose two bristles. "In the larval condition, the crane flies are fearful pests, living just below the surface of the ground, and feeding on the roots of grasses. Whole acres of grass have been destroyed by these larvæ" (Wood). The larvæ, or grubs, known as "leather-jackets," are of a brownish colour, and measure 1½ inches when fully grown. They are devoid of legs, but move by wriggling along, somewhat after the fashion of the earthworm. The larvæ of *Tipula* are injurious to cabbages, beans, lettuces, and corn crops, as well as grasses. The pupæ appear from July to September, at which time hundreds or thousands of empty cases "may often be seen protruding half-way out of the earth amongst grass, and by the sides of gravel walks." The female fly lays eggs during the autumn in or on the ground, and on damp grass. The eggs are oval, black grains.

Prevention.—(1) Good cultivation and liberal manuring to produce healthy and vigorous crops. For suitable manures (for *various* grass lands), see the author's book, *Manures and their Uses*, p. 42. (2) A thorough drainage of damp (and in fact all) lands has a tendency to lessen the attacks of this pest. (3) The "brush-harrow" is useful for preventing the deposition of eggs. (4) Starlings and rooks destroy large numbers of the larvæ of *Tipula*. "Perhaps there is no bird that does so much real good to the husbandman as the starling (*Sturnus vulgaris*), for it feeds upon the most destructive grubs and insects that exist; and therefore this more than compensates for the cherries and elderberries which it eats" (Swaysland). (5) In the case of old pastures, *deep* ploughing buries the larvæ and eggs, and thereby destroys them. (6) Rolling infested grass lands (at *night*) with a Crosskill or Cambridge roller destroys thousands of grubs.

Cure.—(1) Dressings of quicklime or gas-lime have proved useful. (2) Mr. A. Smetham, F.C.S., has shown that "a solution of sulphate of copper (blue vitrol) killed the grubs in about eight to twelve minutes. Sulphate of iron (green vitrol) was more rapid in its effects." (3) Salt has been spoken of by some writers; but it has been shown that the larvæ of *Tipula* are not killed after an immersion in strong brine for twenty-four or thirty-six hours. This is due to their thick and very tough integuments.

The Eelworm of Grasses (*Tylenchus devastatrix*) has already been described. It attacks certain meadow grasses. Amongst these are the following: *Anthoxanthum odoratum* (sweet vernal grass), *Poa trivialis* (rough stalked meadow grass), *Poa nemoralis* (wood meadow grass), *Holcus lanatus* (Yorkshire fog, or woolly soft grass), etc. There is little doubt that this species of *Tylenchus* causes considerable damage to grasses, as well as other farm crops.

The Grass Weevil (*Rhynchites bacchus*) belongs to the *Rhynchophora*, one of the most extensive, as well as one of the most destructive, groups of the *Coleoptera* (beetles). Various members of this group do immense damage to trees, fruits, grains, etc. For instance, the corn weevil does much mischief in granaries; the nut weevil eats a hole in the soft nut, in which it deposits an egg, which, turning to a larva, eats the kernel, and leaves only the bitter, dusty contents; the pea and bean weevils (already described), which spoil the prospects of the usual accompaniment of roast ducks, all belong to what are known as the long-nosed *Rhynchophora*. The small grass weevil (*Rhynchites bacchus*) is a mischievous insect in the meadows and pastures of France and Germany rather than in this country. Although a farm pest, especially in the green pastures of Normandy, it is principally one of the chief enemies of the *vine*. In the words of the late Rev. J. G. Wood, M.A., "the grass weevil commits terrible devastations among the growing vines, sometimes stripping the bushes of their leaves, which it rolls up and lines with silk."

The Cockchafer (*Melolontha vulgaris*, Fig. 35) is so familiar an object, that it hardly needs description here. The white or cream-coloured larvæ of this beetle feed upon the *roots* of grasses and other plants, "and when in great numbers have been known to ruin an entire harvest. To turf they are especially destructive, shearing away the roots with their scissor-like jaws, and killing the vegetation so effectually that the turf withers, turns yellow, then brown, and can be taken up and rolled by hand."[1] The larva of this insect is an exceedingly fat grub, about an inch and a half in length, and the thickness of one's little finger. It is provided with strong jaws, six jointed legs, and occasions considerable damage to grass lands during the *three* years it remains in the larval form. In the summer of the third year the grub burrows to a depth of three to four feet below ground; and in this retreat it makes a sort of cocoon formed of particles of the surrounding materials, agglutinated together by a sticky secretion. Within this cocoon the larva turns to the pupal stage, finally changing to a perfect insect during the summer of the fourth year. The beetle (which feeds on the leaves of the vine, as well as those of the elm, oak, and other trees) is about one inch in length, of a blackish-brown colour. The abdomen has white stripes and ends in a tip (curved ventrally), which projects beyond the elytra (Fig. 35). The antennæ are terminated by clubs composed of seven leaf-like joints in the male, and six in the female. "In their perfect state the cockchafers only live about a week, and during this time they frequent trees, and feed upon the leaves. The female, however, when ready to

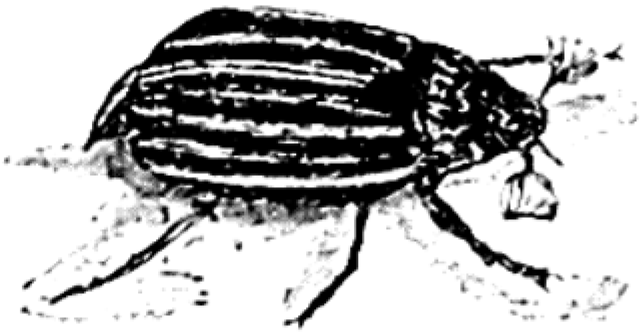

Fig. 35.—COCKCHAFER (*Melolontha vulgaris*).

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[1] Wood's *Illustrated Natural History*, vol. iii. p. 467.

deposit her eggs, burrows down into the earth to a depth of about six inches, where she leaves them; and in the course of about a fortnight the young larvæ are hatched, and proceed in search of nourishment."

Prevention.—(1) Hand-picking would help to a certain extent in keeping down this pest. (2) Pigs, ducks, and poultry readily devour the grubs, as well as the beetles. (3) Starlings, rooks, crows, nightjars, redstarts, and other insectivorous birds make "sad havoc" amongst these farm pests; therefore they should be protected from injury. It is most probable that the wholesale destruction of injurious insects by birds[1] more than compensates for the small amount of damage the latter may do to various crops and fruits.

Cure.—Dressings of quicklime, gas-lime, and drenchings of ammoniacal or gas-liquor (diluted with four or five times its bulk of water) destroy large numbers of the larvæ of the cockchafer. The liquor can easily be applied by means of a water-cart. "In very dry weather gas-liquor 'burns up the grass,' but on the first appearance of rain the herbage will again spring up with increased luxuriance" (*Treatise on Manures*).

The Click Beetles (*Elater sputator*, *Elater obscurus*, *Elater sanguineus*, *Elater lineatus*, Fig. 36) belong to the *Elateridæ*, and "may readily be known by the hinder angles of the thorax being pointed, and also by their power of jumping up, with a slight clicking noise, when laid on the back. Most of the species are black, or bronzed, or partly black and partly yellow. *E. sanguineus* (Fig. 36 C) is a bright-scarlet insect, with a black head and thorax. The beetles are commonly met with on flowers, etc., in the daytime; and their larvæ are too well-known everywhere, as WIRE-WORMS, being long and slender, with very tough skins, and feeding on the *roots* of plants." The wire-worms gnaw, and sometimes destroy to a serious extent, the roots of various farm crops (grain and root, as well as fodder crops). The larvæ (wire-worms) of the skip-jacks, or click-beetles, are long, slender, and either slightly flattened or cylindrical, usually covered

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[1] "Insectivorous birds appear to have an instinctive knowledge of the position of the larva below the surface."

Tam Kirk (Dogg)-
a very wicked
person

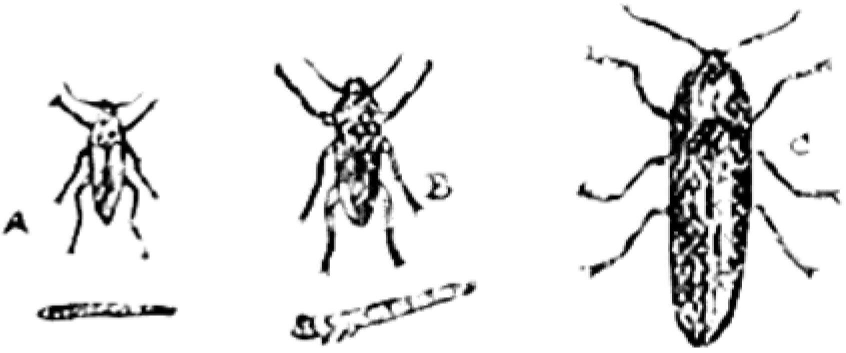

Fig. 36.—CLICK BEETLES AND WIREWORMS.

A. *Elater sputator* and larva.
B. *Elater obscurus* and larva.
C. *Elater sanguineus.*
(All nat. size.)

with a hard, shining, ochre-coloured skin, and furnished with a horny head and three pairs of short legs. They live either three or five years, according to the supply of food. A scarcity of food means a prolonged existence in the larval stage. In the winter the larvæ go deeper in the soil, to avoid the severity of frosts. At the expiration of the larval period, the wire-worms again go deeper in the soil, surround themselves in earth-cells, and there change to pupæ. The pupæ either hibernate until the following spring, or appear as perfect insects in from fourteen to twenty-one days during the month of August "The eggs from which these grubs are hatched are laid either in the earth close to the root of a plant, or between the sheathing leaves near the base of the stem."

Prevention.—(1) Good cultivation and liberal manuring[1] produce strong and vigorous plants, which may yield, in spite of the land containing wire-worms, a tolerably good crop; for it is said that the "wire-worms injure and weaken a great deal more than they destroy." (2) Burn all rubbish on which the wire-worms may possibly feed. (3) The common mole and the various insectivorous birds (especially the "wheat-ear") are the natural enemies of the wire-worm. Mr. W. Swaysland, in his *Familiar Wild Birds*, cites "as an instance of the service rendered to the farmer by the 'wheat-ear' (*Saxicola œnanthe*) and similar birds," that he "remembers a field about eight acres in extent which one season was so infested with *wire-worms* that cultivation was almost useless. The field was ploughed and harrowed about the end of April, or the beginning of May, and at this time large numbers of 'wheat-ears' congregated there daily; in fact, they seemed to have forsaken the surrounding localities for this particular spot. Their services in the extirpation of the above-mentioned wire-worms may be best imagined from the fact that after the advent of the birds the field became productive, and a first-rate crop was the result of their labours and assiduity."

Cure.—(1) The soil from broken-up pastures, etc., should be dressed with fifteen tons of gas-lime per acre. The sulphite and sulphide of lime present in gas-lime destroy the wire-worms, as well as other insects and weeds. When the land is ready once more for cultivation (*i.e.*, in about three or four months), the sulphite and sulphide will have been converted into sulphate of lime (a true plant-food) by the action of the air. (2) Twenty or thirty bushels of salt per acre have been recommended for eradicating wire-worms. (3) Miss Ormerod recommends the use of rape-dust or rape-cake "applied in the proportion of five hundredweights to the acre." The "worm" is believed to be very fond of the cake, eating it greedily in preference to farm crops. (4) Paraffin oil mixed with water (1 to 20) has proved an effectual remedy, especially for infested root crops. (5) Green manuring with buckwheat or white mustard, destroys the wire-worms as well as the mustard beetle.

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[1] For the most suitable manures, see *Manures and their Uses*, p. 42 (Bell's Agricultural Series).

The Skippers (*Hesperia linea*) belong to the *Hesperidæ*—a family of butterflies which (as a general rule) carry their fore-wings upright, and their hind-wings in a horizontal position when at rest. *H. linea* measures about an inch across the extended wings. The wings are of a bright yellowish-brown colour, with the margins and veins blackish. These butterflies are popularly known as "skippers"—so called from their short, jerky flight. The larvæ or caterpillars feed upon different species of grasses, but do not produce the same amount of mischief as the wire-worms.

Moss in Pastures. The various kinds of mosses[1] infesting grass lands hardly come under the designation of "parasites," yet at the same time they are detrimental to the growth of grasses; and for this reason we include them among the enemies of grass lands. By the growth of moss in pastures, the grass becomes poor in quality and quantity.

Prevention.—(1) As mosses require a considerable amount of moisture for their growth and development all meadows and pasture lands should be well drained. "Wherever there is *moisture*, even if soil be almost absent, mosses will grow; and they are the first to cover a barren coast, as they are the last to linger when the atmosphere ceases to be capable of affording nourishment to vegetation" (Dr. E. Smith, F.R.S.). (2) The growth of mosses also indicates a want of good cultivation, especially in the use of the most suitable manures for grass lands.

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[1] For the life-history of a moss, see any good book on botany.

Cure.—(1) The author has shown (*Journal Chemical Society*, 1886, p. 114) that iron sulphate destroys *moss* infesting pasture lands. After having applied a top-dressing of iron sulphate to the land, the grass turned black after the first rainfall, but in a fortnight became a bright green colour, and the moss was destroyed. The bright green appearance never altered in the least throughout the summer, although the summer (1885) was rather a dry one. The above grasses and mosses gave the following percentages of iron oxide in their ashes:—

ASHES OF GRASS AND MOSS.

	Before the addition of iron sulphate to the land.		After the addition of iron sulphate to the land.	
	Grass.	Moss.	Grass.	Moss.
Iron oxide ($Fe_2 O_3$)	0·45	6·62	2·46	11·56

The analysis of the ashes of the *moss plants* after the addition of iron sulphate shows the percentage of iron oxide is 11·56. "The moss, being of a greedy, thirsty nature, took up more than was good for it, and, like some human beings who do the same, came to an untimely end." In a paper published in the *Chemical News* (vol. 50 p. 193), the author showed that all the plants under investigation died when they had absorbed iron salts to the extent of yielding 10 per cent. of iron oxide after incineration. Hence the reason the mosses were destroyed (by the iron sulphate), being plants naturally requiring a larger amount of moisture than the grasses.

The above results have been confirmed by Professors Lambin, Bernard, Quantin, Joulie, Gaillot, Néron, Delacharlonny, Tord, Jaubert, and others in France,[1] as well as by several well-known agriculturists in this country. Professor Lambin says: "Les résultats observés à Soissons confirment ceux obtenus par M. Griffiths. Ces résultats répondent en même temps aux craintes manifestées sur l'emploi du sulfate de fer en agriculture. Non seulement sous l'action d'une dose de 250 à 300 kilogrammes par hectare les plantes n'ont pas souffert, mais elles ont largement prospéré, le rendement de la prairie ayant été presque doublé." Mr. Macqueen, home farmer to the Earl of Powis, considers iron sulphate "an excellent manure for mossy pastures."

The quantity of iron sulphate to be applied for eradicating moss, is from 1½ to 2 cwts. per acre. The powdered sulphate should be mixed with two to ten times its weight of sand or dry soil, and distributed by hand, manure distributor, or better still by means of the Strawsonizer. The sulphate may also be applied by means of a water-cart.[2] Farmers would do well to purchase the iron sulphate (of a grass-green colour) from the nearest maker, in the *crystalline* form, and powder it themselves; this would prevent adulteration. (2) Lime has also been recommended for eradicating moss, but its action is not so certain as that of iron sulphate.

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[1] See *Journal de l'Agriculture*, September, 1887, October, 1888; *Bulletin de la Société d'Horticulture de Soissons*, 1887; *Bull. Soc. des Agriculteurs de France*, 1888; also *Manures and their Uses*, p. 182, and *A Treatise on Manures*, p. 275.

[2] Dissolve either of the above quantities of iron sulphate (green vitriol) in 40 gallons of water.

The Coronated Mildew of Grasses (*Puccinia coronata*, Fig. 37) is similar in its life-history to the "mildew of corn" (wheat), which will be described later in this chapter. *Puccinia coronata* produces numberless oval-shaped spots on various grasses. The sori (Fig. 37 B and *a*) are crowded together, and ultimately rupture the epidermis of the host-plant.

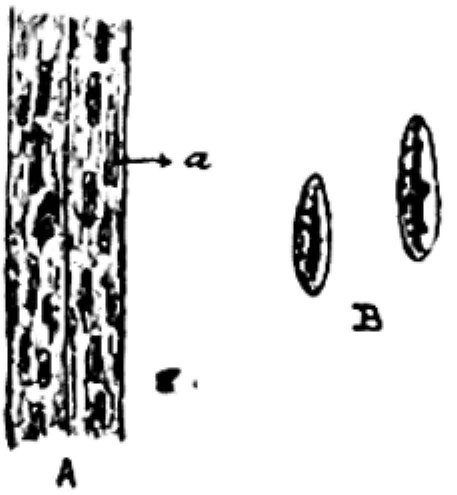

Fig. 37.—Coronated Mildew (*Puccinia coronata*).
A. Sori on grass (enlarged).
B. Sori (enlarged).

Prevention and Cure.—(1) The drainage of grass lands has a tendency to lessen the ravages of this fungoïd pest. (2) Top-dressing pastures and meadows with ½-cwt. of iron sulphate, mixed with five to ten times its weight of sand or dry earth per acre, is a means of destroying the mildew of grasses.

The Grass-Culm-Smut (*Ustilago hypodytes*) belongs to the *Ustilagineæ*, an important group of fungi whose mycelia usually spread throughout the tissues of the host-plant. In this point the *Ustilagineæ* differ from the localized mycelium of most *Uredineæ*. The grass-culm-smut, which is sometimes common, "makes its appearance at first beneath the sheaths of the leaves surrounding the stems of grasses, and ultimately appears above and around them as a purplish-black dust." The minute spores of this fungus are of a brownish-black colour.

Cure. — See the method for destroying *Puccinia coronata.*

The Smut Fungus (*Ustilago carbo*), which will be fully described under "The Parasites of Oats," has been found on the following grasses amongst others: *Aira cæspitosa* (hair grass), *Avena flavescens* (yellow oat grass), *Avena elatior* (false oat grass), *Avena pubescens* (downy oat grass), *Festuca pratensis* (meadow fescue), *Lolium perenne* (rye grass), *Lolium temulentum* (darnel grass), *Cynosurus cristatus* (crested dogstail), *Festuca elatior* (tall fescue), *Festuca ovina* (sheep's fescue), and *Dactylis glomerata* (cocks-foot grass).

The Grass Blight (*Erysiphe graminis*) is similar in its life-history to the pea mildew (*Erysiphe Martii*) already described.

Prevention.—(1) Good cultivation, clean farming, and a liberal use of artificial manures are means of preventing the attacks of this fungus. Farmyard manure containing mildewed straws and grasses should not be used for grass lands. (2) Whenever possible burn all mildewed straws and grasses, for these retain the perithecia of this destructive fungus. (3) A thorough drainage of meadows and pastures lessens the risk of infection, not only of this fungoïd growth, but of others as well.

Cure.—A top-dressing of iron sulphate ($\frac{1}{2}$-cwt. per acre) is an effectual remedy.

The Fusisporium of Rye-grass (*Fusisporium lolii*) has a similar life-history to *Fusisporium hordei*, already described. The mycelium of the first-named fungus is of an orange colour, while that of the latter is a deep rose colour.

The Ergot (*Claviceps purpurea*) of rye, wheat, barley, and various *mature* grasses will be described under the heading of "The Parasites of Rye." The hay from ergoted grasses is a dangerous food for farm animals. "Not a few cases have occurred, especially in Ireland and the States of America, 'where hay was found to contain an eighth of its weight of ergot.' The fodder caused abortion and ergotism in cows. As a general rule, 'ergot does not cause abortion, except the fœtus has reached a considerable size in the uterus.'" Prof. Sheldon (*The Farm and the Dairy*, p. 138) says: "Much more commonly than most men think, however, it (abortion) comes from the eating of ergoted grasses, for which some cows seem to have a morbid appetite."

There is a *variety* of ergot called *Claviceps purpurea Wilsoni*, which was discovered by Mr. A. S. Wilson on *Glyceria fluitans* (sweet grass) growing in damp places. Messrs. Plowright & Wilson (*Gardeners' Chronicle*, Feb. 9th, 1884) considered it to be a variety of the ordinary ergot. Dr. M. C. Cooke, on the other hand, looks upon it as a separate species of *Claviceps*, and thereby gives it a higher status than a mere variety.

Prevention.—Farmers should take the precaution to cut grass when in the bloom, rather than in the seeding state; it will then be impossible for ergot to appear.

Cure.—Iron sulphate destroys *C. purpurea* (see later in this chapter).

The Isaria of Grass (*Isaria fuciformis*, Fig. 38) was first described by the late Rev. M. J. Berkeley, F.R.S., in the *Journal Linnean Society* (vol. xiii. p. 175). This fungus occurs chiefly in the South and South-west of England, and appears only to attack certain grasses growing on calcareous and siliceous soils. The reason for the growth of *I. fuciformis* on certain grasses growing on the previously mentioned soils, may be due to the fact that both calcareous and siliceous soils contain (as a rule) smaller percentages of iron oxide than argillaceous soils.

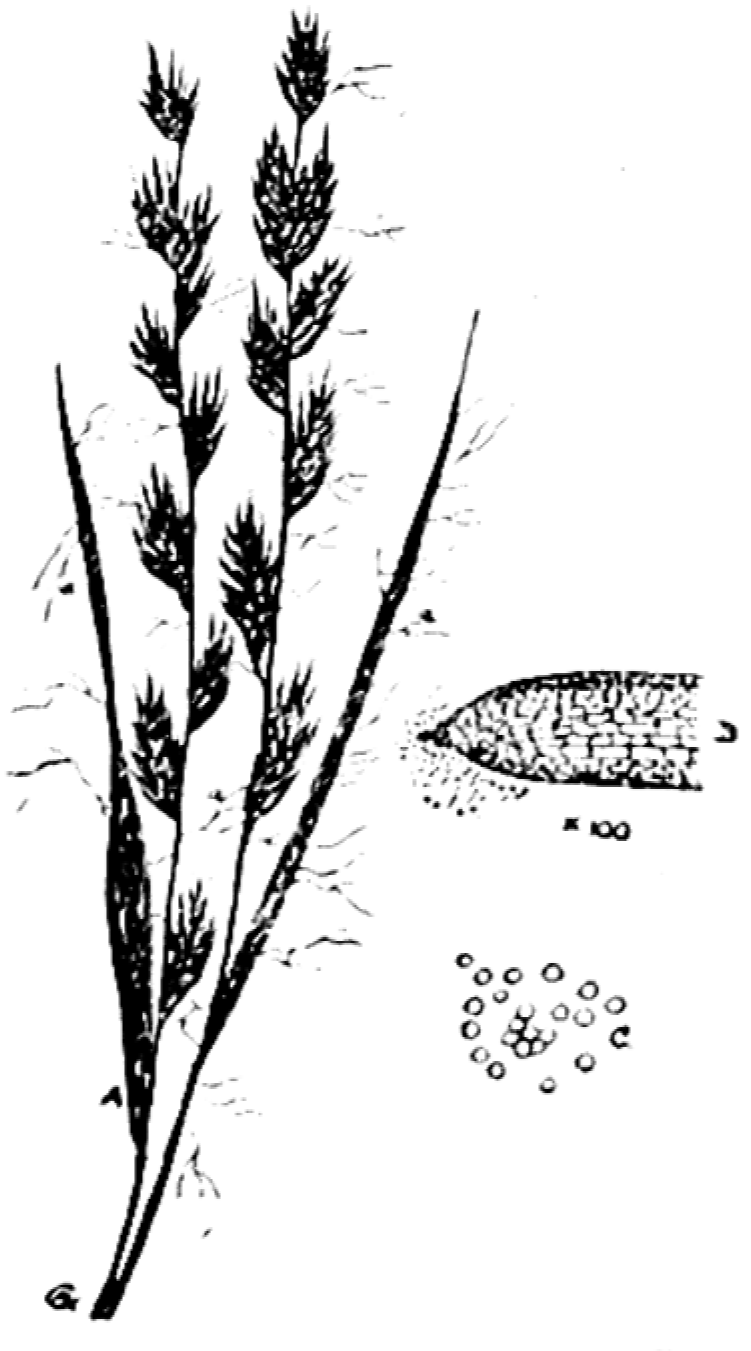

Fig. 38.—ISARIA FUCIFORMIS OF GRASSES

A. A grass infested with the fungus (*a*).
B. End of a fungus tuft (*a*) with conidia (spores).
C. Conidia. × 670 diam. (Zeiss' E., 4oc.)

From the author's researches, compounds of *iron* appear to be detrimental to the growth of most parasitic fungi; and the absence of soluble, or readily assimilable iron compounds in a soil, may produce sickly plants liable to fall an easy prey to the attacks of parasitic fungi. Fig. 38 A illustrates a panicle of grass infested with *Isaria fuciformis*, whose mycelium grows on all parts of the host-plant, especially the leaves and stems, which it often binds together. The fungus is chromogenic (*i.e.*, produces colour)—the colour of the mycelium being from pink to red—and consists of a compact mass of cells which frequently sends out aërial tufts (Fig. 38 *a*). The cells at the extreme ends of these tufts divide and give rise to numberless conidia (Fig. 39 B). These conidia, or spores, germinate on grasses, and again reproduce the mycelium of *I. fuciformis*. The fungus tufts are easily detached, and if they fall upon a suitable medium for development they reproduce the mycelium of the fungus. Very little (beyond what has already been stated) is known of this fungus or its habits. "It is quite possible that *I. fuciformis* may be an early condition of a *Torrubia* belonging to an insect or plant host." Certain species of *Torrubia* infest truffles, mosses, and insects. It has been stated that grass infested with *I. fuciformis* produces a diseased state of the lungs when farm animals are fed upon it; but this statement requires confirmation.

Prevention.—(1) The drainage of all grass lands, especially those in the South and South-west of England, has a tendency to lessen the attacks of this fungoïd pest. (2) As *I. fuciformis* only makes its appearance from September to the following January, it would be well for farmers to remove the grass before the appearance of the fungus.

(4) THE PARASITES OF OATS (*Avena sativa*).

Aphis granaria, *Cephus pygmæus*, *Tylenchus devastatrix*, *Tylenchus Havensteinii*, and various wireworms (which have already been described) attack *Avena sativa.*

The Frit Fly (*Oscinis vastator*, *Oscinis frit*) is a small dipterous insect which attacks barley and wheat, as well as oats. This fly caused serious damage to the oat crops of 1887. It is about $2\frac{1}{4}$ lines,[1] or a little more than $\frac{1}{6}$ of an inch, in length, with a blackish head, thorax, and abdomen. The feet are yellowish, while the haltères (or the rudiments of the posterior wings of other insects) are of a light buff colour. The female fly lays white eggs on the leaves of the above-mentioned crops, from which white grubs make their appearance in a short time. The grubs (like those of *Chlorops tæniopus*, *Cephus pygmæus*) infest the stems of and live upon the soft tissues and juices of corn plants. The grubs of this fly are about $\frac{1}{4}$ inch long, and are devoid of legs. They turn to pupæ of a brown colour; and, according to Dr. Nördlinger (*Die Kleinen Feinde der Landwirthschaft*), the pupæ may hibernate on grasses or in the earth. There are several broods during the summer. In France, Germany, and especially in Sweden, the grubs live on "the growing grain," as well as infest the stems of the host-plants. The ravages of this farm pest are greater during a dry than a wet season.

Prevention.—After oats or any other corn crop has been infested with this insect, ploughing up the land has been recommended as a preventive against a subsequent attack during the next season.

Cure.—It has been suggested, that before sowing oats infested with the brown pupæ of this fly the seed should be steeped in a solution of copper sulphate or common salt.

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[1] 1 line = $\frac{1}{12}$ inch.

The Smut Fungus (*Ustilago carbo*, Fig. 39) produces the well-known black and withered ears of corn. It attacks barley, wheat, and certain grasses, as well as oats. The disease is said to originate in the roots of the host-plants, and passes up the stems into the leaves and panicles. The spikelets (Fig. 39 A) become covered with masses (sori) of black or primary spores, which work their way from within outwards, and ultimately rupture the epidermis of infested plants. The small globular spores are of a dark-brown colour, almost black (Fig. 39 C). These spores give rise to "buds" (Fig. 39 E), which ultimately form secondary spores, or conidia. The secondary spores are produced by what is known as the process of

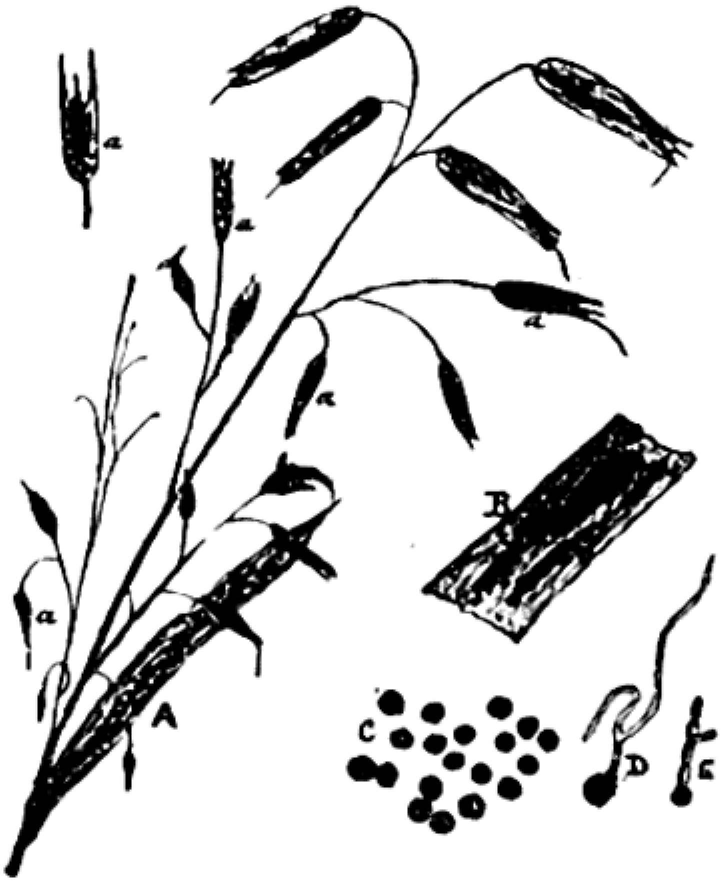

Fig. 39.—The Smut of Corn (*Ustilago carbo*).

A. Oats infested with *Ustilago carbo* (*a*).
B. "Sori" on a portion of a glume of oats.
C. Spores × 320 (Zeiss' D., 3oc.).
E & D. A spore germinating.

gemmation, which may go on indefinitely—so long as the medium in which the spores live is suitable for this method of reproduction. In this respect (*i.e.*, reproduction by gemmation) *Ustilago carbo* resembles the cells of *Torula cerevisiæ* (the yeast organism), and better still those of *Torula apiculatus*. The secondary spores continue producing the same spores, or give rise to germ-tubes (hyphæ, Fig. 39 D) which germinate on, and produce a mycelium within, the tissues of the host-plant. It is possible that conjugation[1] takes place between the spores of the smut fungus, for this method of reproduction is not uncommon in the genus *Ustilago*. The spores of the smut fungus are to be found in the soil, air, and on the seeds of oats, barley, and wheat before sowing.

Prevention.—(1) Destroy all affected ears at the earliest stage when the disease is visible, and before the spores have ripened. (2) "Burn all smutted grasses."

Cure.—(1) The author has shown that steeping the grain before sowing in a 2 per cent. solution of iron sulphate for three or four hours entirely destroys any fungal spores which may be upon the seeds; and this method does not injure the germinating power of the grain. (2) A solution of copper sulphate[2] has often been recommended for the same purpose, but there is little doubt that this reagent frequently destroys the germinating power of seeds (*Biedermann's Centralblatt für Agricultur-Chemie*, 1886, p. 766). Mr. J. L. Jensen (*Journ. Roy. Agric. Society*, 1888, p. 397) says that "dressing cereals with copper sulphate in the usual manner against smut and bunt causes, as a rule, a waste of the seed-corn.

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[1] The production of a spore by the union of two "*like*" cells.

[2] 1 lb. dissolved in 5 quarts of water for 4 bushels of grain.

It is injurious to the plants." (3) Another remedy is to make a strong solution of sodium sulphate (Glauber's salts) "in which the seed-corn is to be washed, and afterwards, whilst still moist, dusted over with quick-lime." The reader who is acquainted with chemistry will readily understand the reaction which takes place by referring to the following equation:—

$$Na_2SO_4 + CaO = Na_2O + CaSO_4.$$

"The caustic soda (Na_2O) is fatal to the germination of the spores of bunt" as well as those of smut. (4) Other "steeps" for destroying the germs of disease are or have been used by agriculturists. Amongst these are the following: Arsenious acid and soda, slaked lime, salt, a weak solution of potassium permanganate, and a weak solution of carbolic acid. But all these substances are more or less detrimental to the germinating properties of grains. Damaged grains produce sickly plants, and sickly plants run the risk of becoming diseased. (5) Mr. J. L. Jensen recommends "treating the seed-corn with water heated to a temperature of 127° F. for five minutes, which destroys the fungal spores without injuring the seed-corn or the resulting crop." But the most effectual and reliable method, in our opinion, is the use of a solution of iron sulphate. The author's investigations on this subject have been confirmed both in France[1] and Germany as well as in England.

(5) THE PARASITES OF RICE (*Oryza sativa*).

The Rice Weevil (*Calandra oryzæ*) belongs to the same genus as the common corn weevil (*Calandra granaria*), the palm weevil (*Calandra palmarum*), and many other destructive species which are plentiful all over the world. The rice weevil is of small size, not more than an eighth of an inch in length, and is well known in the Colonies and India by the characteristic four red spots on the black elytra. This insect is destructive to Indian corn and wheat as well as rice.

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[1] See Prof. Quantin's paper, *Journ. de l'Agric.*, 1888.

On the authority of Mr. C. Whitehead, F.L.S., "*C. oryzæ* does enormous harm to wheat in Indian granaries, and to *wheat* while it is being transported in vessels to this country. The admixture of dirt, seeds, and rubbish causes the wheat to heat, which is detrimental to its quality, and at the same time causes weevils to propagate unusually and to materially damage it. Sometimes the cargoes of wheat that have been heated are nearly alive with weevils, causing great waste and heavy loss to importers. This loss continues when the bulk is taken to granaries or warehouses where the heat is still evolved, and the weevils revel in it. The amount of loss occasioned by this weevil is estimated at an average of 2½ per cent. Taking the value of wheat exported at £6,000,000, the amount of loss due to this insect in exported wheat alone equals £150,000" (*Nature*, vol. 40, p. 841).

There are two principal fungi that cause disease in the rice crops of India and the Colonies. The first is the smut fungus (*U. carbo*) already described; and the second, *Claviceps purpurea* (the ergot of cereals and grasses), which will be described later in this chapter.

(6) THE PARASITES OF RYE (*Secale cereale*).

The Grain Aphis (*A. granaria*) has already been described as an enemy of barley, oats, and grasses.

The Eelworms (*Tylenchus devastatrix* and *T. Havensteinii*), described in chapter ii., cause considerable damage to the rye crops of Germany and Holland. The disease known by the names of "knopf," "rüb," and "stock," is due to injury caused to rye plants by the above-named nematoids.

The Wire-worms, already described, seriously injure rye plants.

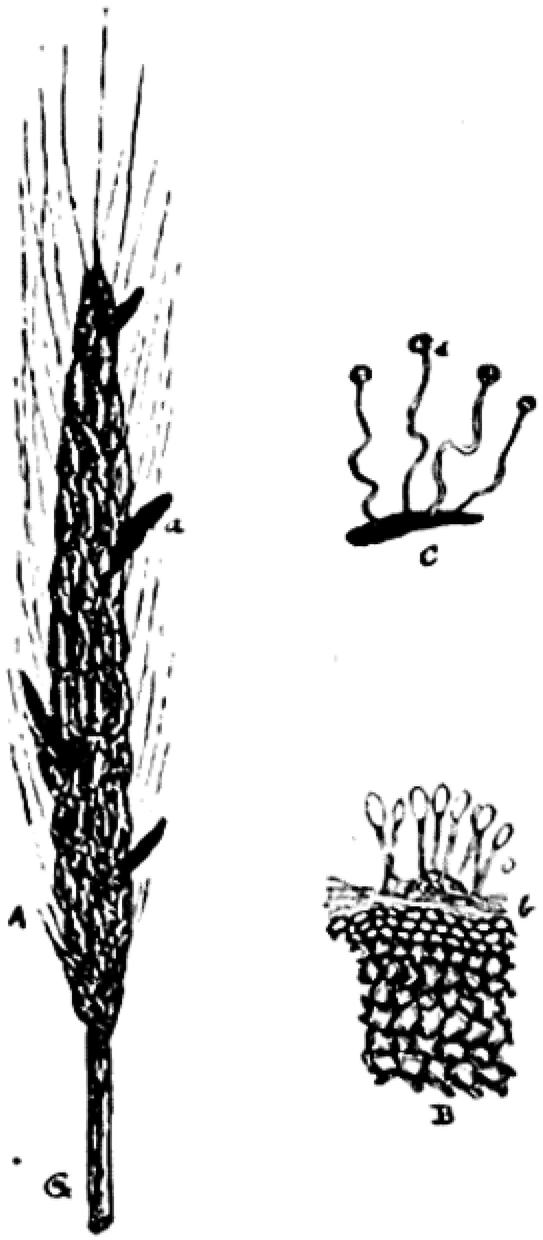

Fig. 40.—The Ergot of Rye, etc. (*Claviceps purpurea*).
A. An ear of rye with ergots (*a*).
B. A section through an ergot (in its *early* condition); at *b* is a mycelium bearing conidia (× 270).
C. A germinating ergot (a sclerotium), (nat. size).

The Ergot of Rye (*Claviceps purpurea*, Figs. 40 and 41) is nothing more than a sclerotium or compact hard mycelium of the above-named fungus. The ergots of rye are so familiar to farmers that little need be said of their external characters. They are elongated blackish growths found on spikes of rye (Fig. 40 A) and other cereals as well as on certain *mature* grasses. A microscopic section through an ergot (Fig. 40 B) shows a compacted mass of irregularly shaped and very thick-walled cells. In what is known as the "early condition," an ergot gives rise to a loosely matted mycelium bearing conidia (Fig. 40 *b*). This early condition was at one time considered to be a parasite of ergot; but it has been demonstrated that the so-called *Oidium abortifaciens* is nothing more than an early stage in the life-history of *Claviceps purpurea*. The oidium-conidia germinate, and reproduce either the oidium-mycelia or the early stage of ergot. When the ergots attain their full size the oidium-mycelia atrophy, and ultimately fall away. Ergots retain their vitality for about two years, and when the surroundings are favourable they germinate (Fig. 40 C). Each

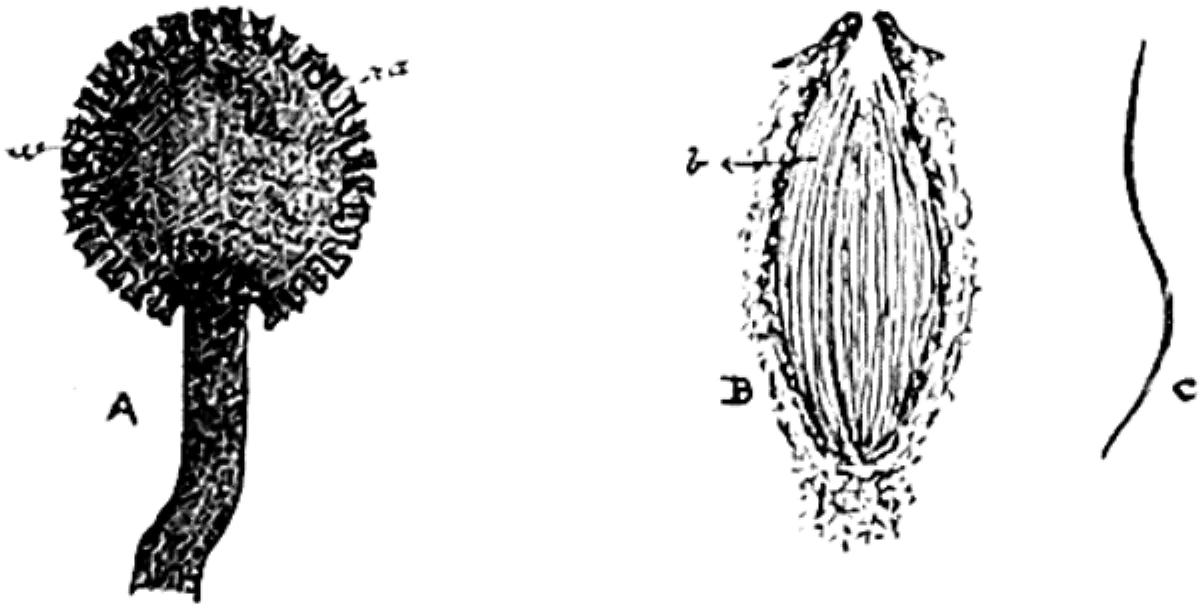

Fig. 41.—*Claviceps purpurea.*

A. A section through the spherical head of the fungus, showing a number of conceptacles (*a*), × about 11 diam.
B. A section of a conceptacle, showing a number of asci (*b*), × 95 diam. (Zeiss' B, and 2oc.).
C. A sporidium. × 270 diam. (Zeiss' E, and 1oc.).

mature ergot gives rise to a perfect fungus bearing small globular heads of a pale violet colour. When a longitudinal section through one of the globular heads is examined under a low power of the microscope, a number of conceptacles are observed round the periphery of the head (Fig. 41 A). These conceptacles, or flask-shaped cavities, open outwards, and each contains a large number of elongated asci ("sacks") containing sporidia (Fig. 41 B and C). In England, these sporidia or spores are produced in June and July; but the *time* for spore-formation must necessarily depend upon the nature of the host-plant and the environment.[1] When the asci are ripe, the contained sporidia are liberated. The latter fall upon the young flowers of rye, where they germinate, and ultimately give rise to ergots.[2] The gradual formation of the compact mycelium (ergot) of this fungus is at the expense of the host-plant, which is greatly injured during the latter stages of its growth. Ergots grow upon wheat, barley, rice, and many grasses.

Ergoted fodder produces abortion and ergotism in farm animals.

Prevention.—(1) A good system of drainage lessens the liability of infection. (2) Farmers should take the precaution to cut grass when in bloom, rather than in the seeding state; it will then be impossible for ergot to appear. (3) In the case of ergoted grasses, a scythe should be used for cutting off their "tops." The latter should be raked together and burnt.

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[1] It is earlier in hot climates.

[2] M. Tanret (*Comptes Rendus* [1889], vol. 108) has recently isolated a new substance from ergots, which he terms ergosterine ($C_{52}H_{40}O_2$). Ergosterine is an alcohol (monoatomic).

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Cure.—Iron sulphate destroys *Claviceps purpurea.* All lands liable to the attacks of this fungus should be top-dressed with iron sulphate (from ½ to 1 cwt. per acre).

The Smut Fungus (*Ustilago carbo*) has already been described under "The Parasites of Oats."

(7) THE PARASITES OF WHEAT (*Triticum vulgare*).

Aphis granaria, *Cephus pygmæus*, *Chlorops tæniopus*, *Oscinis frit*, and the various species of wire-worms, all attack and greatly injure wheat crops. As these insects have already been described, nothing further need be said of them.

The Corn Weevil (*Calandra granaria*) is the pest of corn-dealers, for it passes its "larval state within the grain on which it feeds, devours the whole of the interior, and then, gnawing its way through the shell, becomes transformed in process of time into its perfect state." The beetle, or perfect insect, is about one-sixth of an inch in length, and is entirely of a blackish-red colour. It is found abundantly in granaries, and is brought over (in large quantities) with Indian wheat. It breeds freely in this country—the female laying an egg in each grain of corn visited for the purpose; and the larvæ hatched from the eggs bury themselves in the substance of the grains upon which they feed in security. "When full grown they undergo their change to the pupal state, in the convenient little chamber which they have thus formed, and on attaining their perfect state, make their appearance in the world by eating through the husk of the corn." *C. granaria* is one of the most destructive of the family of weevils. "Besides the actual money loss occasioned by these weevils, it is stated that the flour made from wheat much infested by them is injurious to health."

Prevention.—Infested seeds should not be sown. Farmers should make a practice of examining their seeds—and especially foreign seeds—before sowing or drilling.

Cure. — (1) "Kiln-drying, if judiciously performed, would destroy the larvæ, without affecting the germinating power of the seeds. About 120° F. is held by some authorities to be a safe and sufficient maximum of heat to accomplish this." But it must be borne in mind that kiln-drying is of use only for comparatively *new* seed.

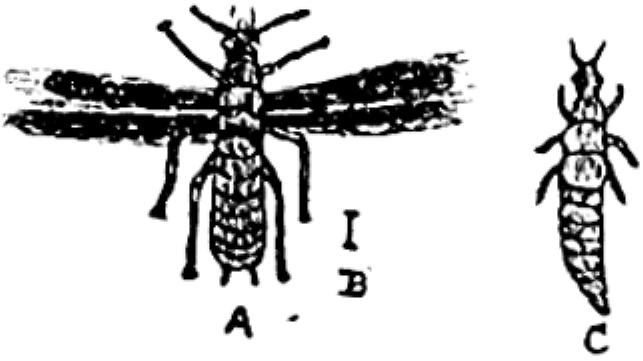

Fig. 42.—CORN THRIPS (*Thrips cerealium*).

A. Corn thrip (enlarged).
B. Its nat. size.
C. Larva of thrips (enlarged).

What would be the use of kiln-drying seeds which have already lost the greater part of the farinaceous matter and possibly the germs damaged by the larvæ of this pest? It is impossible for such seeds to produce anything like satisfactory crops. (2) Washing the floors, etc., of granaries with soft soap and paraffin oil, and limewashing the ceilings, destroy this pest.

The Wheat or Corn Thrips (*Thrips cerealium*, *Thrips tritici*, Fig. 42)[1] belong to the natural order *Physopoda.* The members of this order are generally furnished with four nearly equal, flat wings, destitute of veins; but are provided with very long and delicate hairs, which extend all round the wings. All the species of *Thrips* are remarkable for the "power of executing leaps of considerable extent in comparison with their size, by the agency of their abdomen, which they bend under them, and suddenly extend." *T. cerealium* is a small blackish species, not more than one-tenth of an inch in length, which infests the ears of wheat in all stages of growth. According to Vassali-Enandi (an Italian authority), this insect also "attacks the stems of the wheat plants, gnawing them above the knots." It destroys the plants by extracting their juices—thereby causing a lowered vitality, resulting in disease. The male insect is devoid of wings. The metamorphosis is incomplete, the larva being as active as the perfect insect, to which it bears a close resemblance both in structure and habits. In colour both larvæ and pupæ are yellow, while the perfect insects are black.

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[1] For an excellent account of various species of *Thrips*, see Lindeman's *Die am Getreide Lebenden Thrips arten Mittelrusslands*, pp. 1-42.

Various species of *Thrips* attack grasses, clover, potatoes, hops, and other plants.[1]

Prevention.—(1) As these insects prefer moist situations to dry ones, it is advisable to thoroughly drain all wheat-growing lands. (2) Miss Ormerod states "that *Thrips* do most mischief to late-sown wheat, the early-sown crop being too hard at the time the *Thrips* appear (*i.e.*, in June) for them to injure it." Good cultivation, and the judicious use of manures, are important (although indirect) means of preventing the attacks of this farm pest. Cereal crops generally are greatly benefited by manuring the land with soluble and insoluble phosphates, potash, and nitrogen (either in the form of nitrate of soda or ammonium sulphate). Farmers should bear in mind an old saying attributed to Arbuthnot, that "he who sows his grain upon *sand* will have many a hungry belly before his harvest." When soils are properly manured, healthy and vigorous crops are the result. Such crops are better capable of battling with the various destructive insects than those grown upon impoverished or poor soils.

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[1] Dr. Riley's *Insect Life*, vol. i. p. 141.

The Cockchafer (*M. vulgaris*), one of the largest of the British *Coleoptera*,[1] has already been described as a pest of grasses. The larvæ also feed upon the roots of wheat and other cereal crops, often causing a considerable amount of damage.

The Corn Moth (*Tinea granella*) is found abundantly in granaries in June and July, "when it lays its eggs upon each grain. The young larvæ, when hatched, eat their way into the interior of the grain and feed in concealment upon its substance; but when this portion of food is consumed, each larva unites three or four grains together with a web, so as to form a little habitation, in the interior of which it feeds." *T. granella* belongs to the same tribe as the common clothes-moth.

The Wheat Flour Moth (*Ephestia kuhniella*) has only been known in England about three years. "In 1887 the caterpillars of this moth did great harm in some large stores in London, and in 1888 the attack established itself in a wheat-flour steam-mill in the north of England. The great harm caused is by reason of the caterpillars 'felting' up the meal or flour by the quantity of web which they spin in it. . . . This clogs the mill apparatus to a very serious extent. . . . The moth is about three-fourths of an inch in the spread of the fore wings, which are of pale grey with darker transverse markings; the hinder wings are remarkable for their whitish semi-transparency, with a darker line from the point along a part of the fore edge. The larvæ, when full grown, are about five-eighths of an inch long, of a palish flesh-colour, lighter when older, and heads of a yellowish-brown colour."[1]

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[1] The Rev. Canon Fowler, M.A., F.L.S. (of Lincoln) informs the author that, at least, 100,000 species of the *Coleoptera* are known.

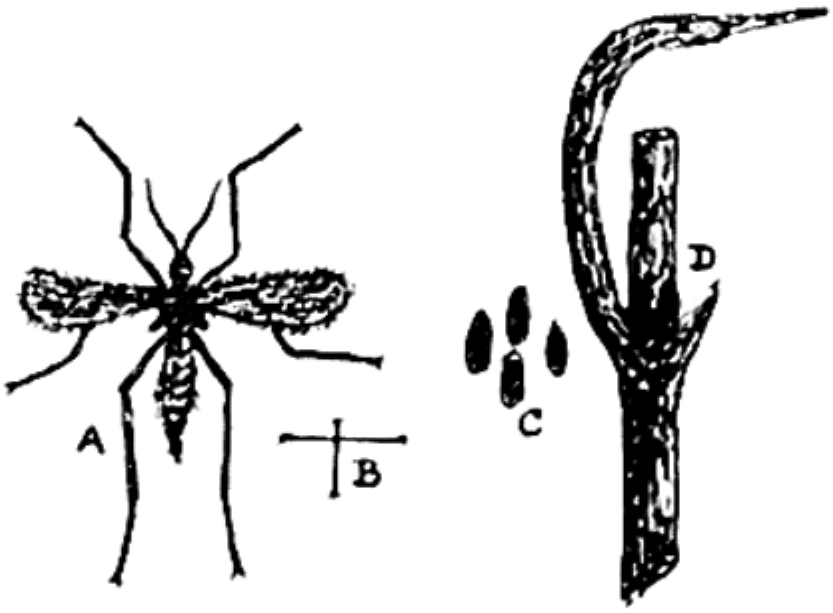

Fig. 43.—The Hessian Fly (*Cecidomyia destructor*).

A. and B. The fly (nat. size and enlarged).
C. Pupa-cases of the fly (nat. size).
D. Pupæ in joint of stem.

Prevention and Cure.—Miss Ormerod writes that she "has much reduced their (the larvæ) numbers by getting the manager of the steam-mill to turn on scalding steam; and cleaning, white-washing, and some use of paraffin have done good. The real cure would be to change the material ground. If we could use rye-meal for a few weeks, we could clean out this wheat-flour feeding caterpillar effectually."

The Hessian Fly (*Cecidomyia destructor*, Fig. 43)

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[1] Miss Ormerod, in Riley's *Insect Life*, vol. i. p. 315.

is one of the most formidable foes of wheat and barley crops; but it does not attack oats. This dipterous fly has been known in the northern continent of America for over a hundred years. The earliest recorded attacks of the *true* Hessian fly in England was in the summer of 1886; although, according to Dr. K. Lindeman (*Die Hessenfliege in Russland*[1]), it was first observed in Russia six years earlier than in Great Britain. As *C. destructor* is often the cause of a wholesale destruction of the wheat crops in America, it has earned the name of the "North American scourge"; but up to the present date the Hessian fly has not done much damage in our islands, where it has confined its attacks to the eastern counties. Although this fly is "an insect of moist climates and mild latitudes," Dr. C. V. Riley says: "that there is very little danger of any such injury in England as is suffered in America and in portions of Continental Europe."[2] Since the visitation of this fly in Great Britain, the damage done by it has been estimated at a loss of one to twelve bushels of grain per acre. The female fly lays its eggs upon the stems of wheat and barley, *i.e.*, between the stem and the leaf-sheath. The eggs (pointed at both ends) are about the one-fifteenth of an inch in length, and of a red colour. The female[3] deposits singly about eight eggs, and then takes flight. These eggs are glued together by means of a sticky secretion. The white larvæ, which are devoid of legs, are hatched from the eggs in fourteen days. After establishing themselves, as a rule, just above the *second* joints, the larvæ feed upon the juices of the host-plants, and weaken them to such an extent, that when the ears begin to be formed, the straw is no longer strong enough to bear their weight, but falls to the ground as though beaten down by strong wind and rain. It must be borne in mind that "the Hessian fly maggot does *not* feed in the ear, nor does it feed along the outside of the upper part of the stem." The ribbon-footed corn fly (*Chlorops tæniopus*) feeds in the ears of corn, etc., and has been mistaken, by some, for the Hessian fly.

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[1] *Bulletin de la Société Impériale des Naturalistes de Moscou*, 1887.

[2] *Insect Life*, vol. i. p. 133.

[3] Each female lays about 230 eggs in a season.

According to Dr. Lindeman (paper *loc. cit.*), the Hessian fly lives about twenty-eight days in the larval stage, it then changes to a brown pupa (Fig. 43 C and D) somewhat resembling a small "flax-seed." Hence the reason that the puparia are sometimes spoken of as "flax-seeds." The period that the insect remains in the pupal stage depends upon circumstances. On the authority of Miss Ormerod, "it may occur, under natural and favourable circumstances, so soon that the whole time occupied in the life of the fly from egg to development is only about forty-eight days"; or, it may hibernate in the pupal stage until May or even later in the following year. The perfect insect (Fig. 43 A) is about five-sixteenths of an inch across the expanded wings and with a body-length of two lines ($\frac{1}{6}$th in.). The head of the male is black, with long brown antennæ and small pink proboscis. The thorax is black with two lines of white hairs running along the dorsal side, and also a few similar hairs on each side of the thorax. The abdomen of the male is black, except at the posterior end, where it is of a pinkish colour. The posterior end of the abdomen "is provided with a pair of claspers of a brown colour, between which are seated the generative organs." The wings, which are of a pink colour at the base, are covered with black hairs. The haltères are of a pale red colour. The female insect is about one-third longer than the male, and has a yellowish-brown abdomen containing a number of spots on each of the eight segments. The legs of both sexes are of a pink colour; but they are of a darker shade in the female.

There are generally two broods of this insect in each season. On the authority of Dr. C. V. Riley, it has been stated that the Hessian fly "is very injurious only under conditions where two annual generations are pretty uniformly produced; and he is satisfied that in England, as a rule, only one generation will be produced." Mr. J. E. Mason, of Alford (who reported the discovery of the pest in Lincolnshire during the season of 1889), wrote the author as follows: "As regards the amount of damage, I have come to the conclusion that in our country it is not at all likely to be serious among the wheat, but that it may be very extensive in the barley crop."

Fortunately for British agriculture there are certain parasites of *Cecidomyia destructor* which accompany it to this country. Amongst these are the following: *Euryscapus saltator*, *Platygaster minutus*, *Eupelmus karschii*, *Tetrastichus Rileyi*, *Semiotellus nigripes*, and *Merisus intermedius*. They are all small four-winged flies, belonging to the *Hymenoptera*, which lay their eggs in the larvæ and pupæ of *C. destructor*. The parasites mentioned infest the Hessian fly in Russia, and therefore must have been introduced into England (along with their host) upon imported Russian wheat. They are quite distinct species from those found in America (Lindeman's *Die Pteromalinen der Hessenfliege*, p. 15).[1]

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[1] For further information, see Riley's *Parasites of the Hessian Fly*, and *Insect Life*, vol. i. p. 132; Ormerod's *The Hessian Fly in*

Prevention.—(1) In those counties (Hertfordshire, Bedfordshire, Lincolnshire, Cambridgeshire, etc.) where the Hessian fly has been pretty active during the past three years, it would be well for farmers, wherever possible, to avoid sowing either barley or wheat late in the season. Early-sown crops appear to resist the attacks better than those late sown. (2) The stout stiff-strawed varieties of wheat and barley resist the attacks of this pest better than other varieties. Among the "resisters" may be mentioned the following: "chaff red," "square head," "stand-up white," "golden drop," "Rivett's red;" and among the barleys should be mentioned: "Kinver," "battledore," "bere," and "awnless." The finer varieties of barley (*e.g.*, "peerless white," "golden melon," etc.) have all been infested in this country. (3) It is recorded that wheat crops (which follow clover in a rotation) grown upon a poor sandy loam, previously manured with fifteen tons of dung per acre, followed by a top-dressing of two cwts. of nitrate of soda and one and a half cwt. of salt per acre in the spring, resisted the attacks of the Hessian fly. On the other hand, a similar crop treated with the same amount of dung *minus* the top-dressing of artificial manures "suffered severely from the attack of Hessian and sawflies." (4) Corn and straw imported into this country should be carefully examined for puparia ("flax-seeds"), and if found they should be burnt. (5) "In corn fields where 'seeds' are not sown, the stubble should be cut as high as possible, in order that the pupæ may be left upon it. Then at once after harvest the land should either be

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Great Britain; Nowicki's paper in *Verhandlungen der K. K. zoologisch-botanischen Gesellschaft in Wien*, vol. xxiv. p. 355; Lindeman's paper in *Entom. Nachr.* xiv. p. 242; Enock in *The Entomologist*, vol. xxi. p. 202.

deeply ploughed, so that the stubble may be buried; or it may be cultivated, or scarified and the stubble harrowed together and carefully burnt" (Whitehead). (6) Farmers should "destroy 'flax-seeds' found (after threshing infested straw) in siftings or light grain." (7) In the United States of America stubbles are burnt as they stand. In some cases this method might be advantageously applied in England.

Cure.—(1) Dressings of gas-lime, in either the autumn or spring, have been recommended for destroying the larvæ, etc., of this pest. (2) Applications of lime, or a mixture of soot and lime, are also recommended for the same purpose.

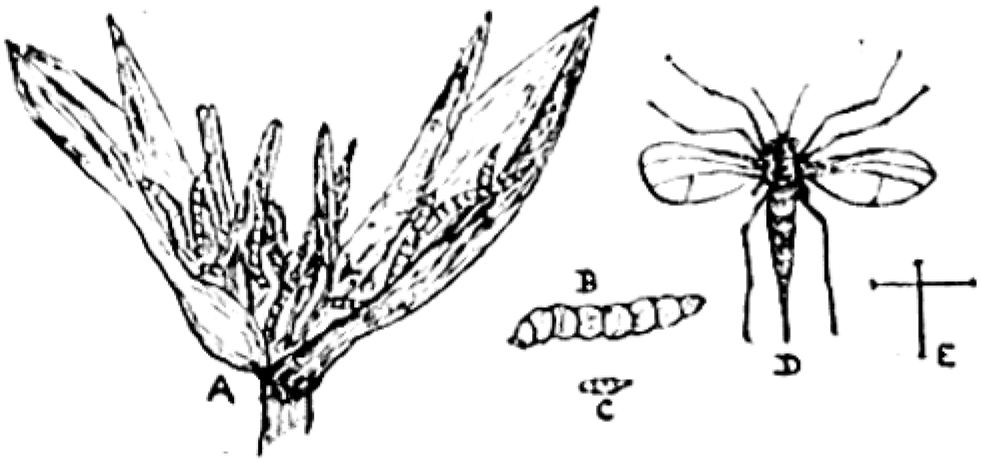

Fig. 44.—THE WHEAT MIDGE OR FLY (*Cecidomyia tritici*).

A. Larvæ feeding on wheat.
B and C. Larvæ (nat. size and enlarged).
D and E. The fly (nat. size and enlarged).

The Wheat Midge (*Cecidomyia tritici*, Fig. 44) belongs to the same genus, and is therefore a near relative of the Hessian fly. It is a small, pale, orange-coloured fly, with clear, almost veinless wings. The female fly visits the florets of the wheat just as they are opening, and deposits its eggs amongst the reproductive organs of the florets, by means of a long, extensible ovipositor. The eggs (which are oblong and transparent) are hatched in about ten days. The small red larvæ (called "red gum" by farmers) from these eggs feed upon the "germs" of the florets, which often renders them abortive. It is said "that as much as five per cent. of the crop is frequently destroyed by this injurious insect." When full-grown, the larvæ go down to the ground, and are there transformed into reddish-coloured pupæ. The pupæ either hibernate or turn to perfect insects during the month of June (*i.e.*, according to whether the brood has been a late or an early one).

Prevention.—(1) Deep ploughing. (2) Destroy those grasses (especially *Avena fatua* [wild oat grass]) upon which the larvæ of the wheat fly feed. (3) As a number of larvæ may be in the ears of corn, it is advisable that the chaff, etc. (after threshing), should be carefully examined. If any maggots are found, they should be destroyed. (4) The firing of infested stubbles has been recommended.

Cure.—See those mentioned for destroying the Hessian fly.

The Wheat Bulb Fly (*Anthomyia coarctata, Musca coarctata*) is a grey-coloured fly, about one-third of an inch in length, and measures half an inch across the extended wings. According to Megnin (*L'Insectologie Agricole*), the tarsi of the females are of a red colour, whilst those of the male are black. The white larvæ, or maggots, are about the same length as the body of the perfect insect. They are devoid of legs, but are provided with "teeth" and "hooks" at their posterior ends. The larvæ of this fly turn to brown-coloured pupæ in the earth. During the season "there are two generations. One is commenced by eggs laid upon autumn-sown wheat plants. Flies of the second generation appear again in the early part of the summer, and place their eggs, it is presumed, upon backward and spring-sown corn, or upon grasses." The larvæ of this fly live within the bulb of the wheat stems.

Prevention.—In districts liable to the attacks of this pest, wheat should not be sown too early.

Cure.—Dressing the land with gas-lime, or quicklime, and soot destroys the pupæ.

Ear-Cockles in Wheat (*Tylenchus tritici*). In the disease known as "ear-cockle," "pepper-corns," and "purples," the grains of corn in the spikelets become replaced by galls of blackish hue. The galls are produced by a small nematoid, the *Tylenchus tritici* of Dr. H. C. Bastian, F.R.S. (*Monograph on the Anguillulidæ*, and *Memoirs on the Nematoids: Parasitic and Free*). This nematoid belongs to the same genus as those already described under the name of "eelworms." The galls are always to be found within the pales and flowering glumes of infested wheat; and, according to Dr. Devaine (*Recherches sur l'Anguillule du Blé nielle*), are "formed from any of the growths belonging to the central part of the flower." Grains affected in the growing crop turn first dark-green, then nearly black. They become misshapen, acquire the form and size of peppercorns, and very nearly resemble cockle-seed and wild vetches. The vetch has a smooth skin, whereas the ear-cockle has a rough surface. If seen in the standing corn, they may at once be recognised, as the glumes (chaff) of the diseased grains are spread open to an abnormal degree, while the awns are considerably twisted. If one of the mature diseased grains is cut in two, it will be found to contain a mass of white, cottony-looking substance, which so resembles the meal found in wheat as to be passed by the ordinary farmer as such. If a small portion of this cottony-looking substance is placed in a drop of water, and examined under the microscope, it will be seen that there are a number of minute worms, which twist and wriggle about in the most excited manner. No sooner does the moisture dry up than they at once become inactive, and remain dormant until again supplied with water. These small nematoids are capable of being dried and revived many times before they are killed. "They have the extraordinary faculty of retaining vitality for many years, even though they are perfectly desiccated. Four or five years is by no means an uncommon duration of life in such conditions." Mr. W. Carruthers, F.R.S., states "that vitality was restored in some eelworms (of a different species) after they had been in the botanical department of the British Museum for more than thirty years."[1] A fully grown *Tylenchus tritici* is about the one-sixth of an inch in length. The sexes are separate, and pairing takes place within the host-plants, where large numbers of microscopic eggs are deposited. These eggs are hatched in about fourteen days, and quickly grow into the cotton-like masses previously described. *T. tritici* infests also oats, rye, maize, and certain grasses.[2] These nematoids are propagated to an unlimited extent when a few ear-cockle grains are sown among seed-wheat. It has already been stated that these "worms" are capable of being desiccated without losing their vitality; and when the surroundings are favourable, they travel through the soil to the adjacent wheat plants, ascend the stalk until they reach the flowers, where the attack commences.

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[1] See also Bastian's paper in the *Transactions Linnean Society*, vol. xxv.

[2] *Festuca elatior* (tall fescue), *Agrostis stolonifera* (fiorin grass), *Agrostis vulgaris* (bent grass), etc.

Prevention.—(1) The land should be well drained, for these pests love moisture. (2) The farmer should use every precaution. If once his farm is infested with this pest, he will find great difficulty in exterminating it. Fortunately the galls containing the "worms" are easily detected (being black and only half the size of wheat-grains) among seed-wheat; but they are not all separated from the chaff by winnowing, for many are blown over with the chaff, and thus propagate the pests when put on the land with the manure. When the cottony mass from a quantity of wheat affected with ear-cockle is extracted in the grinding process, it does not kill these minute organisms, so that they are cast aside with the bran, and thus too often find their way back to the fields. Grain that is only roughly ground for farm animals is still more liable to be a means of spreading the pest. As stated before, numbers of ear-cockles are blown over during the process of winnowing; and under such circumstances, the chaff contains a whole host of what will prove to be, if caution is not practised, parents of a future generation. The only way to destroy them is to *burn the chaff.* (3) Top-dressing the land with the following mixed manure—1 cwt. each of kainit, nitrate of soda, superphosphate of lime, and 1½ cwt. of salt per acre—proved most beneficial (for wheat) on certain farms previously infested with this pest.

The Wheat Milliped (*Julus londinensis*), like *J. terrestris* (already described), is one of the so-called false wire-worms. The wheat milliped has shorter antennæ than *Julus terrestris*, and, unlike the latter species, the pre-anal segment is rounded. *J. londinensis* feeds upon the roots and rootlets of wheat plants.

Prevention and Cure.—(1) Green manuring with buckwheat destroys this pest. (2) Top-dressings of quicklime or gas-lime also kill the wheat milliped.

Trombidium trigonum is a small arachnoid or "spider," and, on the authority of Curtis, injures the spikes of corn, especially in France. On the other hand, Mr. Walker and others in England assert that it feeds upon the aphides that infest ears of corn, but does not injure the corn.

The Wheat Blight, or White Rust (*Erysiphe graminis*), "forms a white superficial mildew on the living stems and leaves of cereals and other grasses in the summer and autumn." It has already been described in chapters ii. and iv.

The Smut Fungus (*Ustilago carbo*) has been described in the present chapter; "but how smut infects *wheat* has long been a mystery. The spores ripen in the young flowers, and have disappeared long before the grain is mature. Attempts at infection of the grain or seedling are almost always unsuccessful. . . . The experiments of Jensen render it most probable that the plant is infected by the spores while flowering, and that either the ovum itself is entered by the mycelium, or that the spores remain dormant in the grain until its germination, and that then the parasite 'grows with the growth and strengthens with the strength' of the young plant" (Dr. Scott).

The Straw Mildew, or Blight, is the cause of a well-known diseased condition of the *stems* of numerous members of the *Gramineæ* (barley, rye, wheat, and various grasses). The *complete* life-history of the straw blight is unknown, but only that portion which is called the vegetative or "larval" condition of a fungus. This fungus attacks the stems near the roots; it seldom extends further than the third joint, and is frequently found below the second. The "straw blight" (as far as is known) simply consists of a ramifying mycelium, whose hyphæ pass through the cell-walls of the host-plant, and thereby greatly injure the infested plant. The fungus often stops growth, and sometimes proves fatal to plant-life. Infested crops are considerably reduced in quantity as well as quality. Upon this point the following facts may be recorded:—

During the seasons of 1887 and 1888, the auther grew meadow hay upon a sandy loam which had previously grown barley. Before laying down for grass, the soil was well manured with farmyard manure, and during the early spring (1887) the grass was top-dressed with a mixture containing 1 cwt. each of guano and sodium nitrate, and 2 cwts. of superphosphate of lime per acre. In May of the same year, the grass was top-dressed with ½ cwt. of iron sulphate per acre. At the harvest (June, 1887), the crop yielded 2 tons 8 cwts. of hay per acre. In the autumn of 1887 the same land was treated with 10 tons of farmyard manure per acre, and in the early spring of 1888 received a top-dressing of the previously mentioned "mixed manure," *minus* the iron sulphate. As the spring advanced, it was observed that nearly the whole of the grass was, more or less, infested with the so-called "straw blight." As it was interesting to compare the yield, etc., of hay from the infested field with the previous year's crop, only a very narrow strip of grass was top-dressed with iron sulphate (½ cwt. per acre) to observe its effect upon the mildew. At the harvest (1888) the infested field yielded 1 ton 9 cwts. of hay, or a reduction of 19 cwts. per acre on the previous year's crop. Fair samples of hay (dried at 100° C.) from each crop gave on analysis the following results:—

		1887 Crop (not infested).	1888 Crop (infested).	Difference.
Albuminoïds (flesh formers)		11·24	8·31	2·93
Soluble carbohydrates	Heat and fat producers	45·61	42·36	3·25
Woody fibre		33·02	38·98	5·96
Fat		3·11	3·04	0·07
Ash		7·01	7·31	0·30
		99·99	100·00	—

The above table shows that the most valuable constituents (albuminoïds and soluble carbohydrates) are considerably reduced in the hay from the infested crop; while the woody fibre[1] is increased by nearly 6 per cent. It must be remarked that the spring and early summer of 1887 were *dry*, while those of 1888 were *wet*, and therefore promoted the growth of the straw blight. After the previously mentioned strip of grass land had been treated with iron sulphate, the grass became healthy and developed a bright-green colour. Microscopical sections of this grass were examined, but not the slightest trace of the straw blight was perceptible.

The straw blight, as already stated, attacks cereals as well as grasses. It is sometimes prevalent (especially in wet seasons) in the spring and summer, and may be recognised by the appearance of *brown spots near the base* of infested stems.

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[1] Woody fibre is digested with difficulty by farm animals.

Prevention.—The drainage of the land lessens the attacks of this pest.

Cure.—Top-dressing the land with iron sulphate destroys this fungoïd growth.

The Bunt of Wheat (*Tilletia tritici*, *Tilletia caries*) is a fungoïd disease which confines itself to the grains within the ears. Infested grains are of a darker green colour, besides being shorter and wider than healthy ones. The interior of an infested grain consists of an exceedingly large number of brownish-black spores possessing a putrescent fishy odour. These dark-coloured spores are globular and slightly spinulose. They either give rise to a short mycelium (pro-mycelium) which bears eight or ten elongated sporidia; or go on branching and rebranching. Each mature sporidium throws out a lateral process, which unites with a similar process of the nearest sporidium (*i.e.*, two sporidia coalesce or conjugate). After conjugation, they become detached from the pro-mycelium, and either germinate, producing secondary sporidia, or produce mycelial hyphæ. The secondary sporidia are also capable of germinating, and either give rise to tertiary sporidia, or they may produce a ramifying mycelium bearing a large number of sporidia of the first and second order. The secondary and tertiary spores also germinate, and give rise to short hyphæ which bear the first or true bunt spores.

As the bunt spores of this fungus hibernate in seed wheat, the wheat plants become affected from the beginning. These spores germinate, and ultimately give rise to the various sporidia and mycelia (already described) "on and in the ground." The last-formed mycelia (from the secondary and tertiary sporidia) find their way into the host-plants through the first-formed stomata. When once within the host-plant, the fungus ultimately finds a resting-place in an ear of corn. Within the grains of wheat the bunt spores are produced.

This fungus (known as "smut balls," "bladder-brand," "stinking smut," etc.) often causes no small amount of damage to our wheat crops. *Tilletia tritici* rarely attacks barley, but is common on wheat.

Prevention.—Bunted grains should not be sown or drilled.

Cure.—(1) As bunted grains often burst among healthy ones, and thereby cover (more or less) the latter with spores, it is advisable for the farmer to "pickle" his seed before drilling. By steeping the seed wheat in a 2 per cent. solution of iron sulphate for three or four hours, the spores of bunt are completely destroyed. (2) A solution of copper sulphate has been recommended for the same purpose; but it (like many other "steeps" used by agriculturists) often destroys the germinating properties of the seeds.

The Fusisporium of Wheat (*Fusisporium culmorum*) attacks the ears of wheat, covering them (more or less) with a pale yellow-coloured mycelium. This fungus has a similar life-history to *F. hordei* (of barley), which has already been described.

The Spring Rust of Corn (*Puccinia rubigo-vera*), generally known as the "corn mildew," produces the familiar red spots ("rust") on the leaves and stems of certain genera of the *Gramineæ* in the spring, and black spots (mildew) in the autumn and winter. The first stage of the life-history of this fungus is termed *Uredo rubigo-vera*, and the second, or mildew stage, is the *Puccinia rubigo-vera.* The first, or "rust" stage, is common on cereals and certain grasses in the spring months. If an infested leaf of wheat is examined under a low power of the microscope, it will be seen covered (more or less) with sori somewhat similar to those of *Puccinia mixta* (see Fig. 18 A and B). These sori of a bright-yellow colour rupture the epidermis of the leaf. If a transverse section of a small sorus is examined under the higher powers of the microscope, a mass of oval-shaped spores is easily discovered, supported on erect hyphal filaments rising from a densely matted mycelium which passes between the cells of the host-plant. The yellow spores (uredospores) of this fungus are liberated by bursting the epidermis of the infested plant. These spores are wafted about by air currents, and may ultimately fall on the leaves of wheat plants, where they germinate by giving rise to hyphæ. These hyphæ pass into the interior of the infested plants through the stomata. The production of mycelia and spores goes on for many weeks.

Later in the season the *Uredo* spots disappear, and black spots, belonging to the second stage in the life-history of this fungus, make their appearance. These small black spots are the sori of the mature *P. rubigo-vera*, and are seen upon an infested wheat-stem. When these sori are examined under a low power of the microscope they have a similar appearance to those represented in Fig. 37 B. If a thin transverse section of a small sorus is magnified 100 diameters, an appearance somewhat resembling Fig. 18 C will be observed. The epidermis of the host-plant is ruptured at certain points where compound spores (teleutospores) protrude. The teleutospores are supported on erect (more or less) hyphæ rising from a densely matted mycelium (spawn). The teleutospores (resting-spores) of *P. rubigo-vera* are developed in the autumn, and then hibernate until the following spring.

In the spring they germinate on decaying gramineous plants, giving rise to a short pro-mycelium. The pro-mycelium produces yellow-coloured spores, which germinate on damp surfaces. These yellow-coloured spores are said to ultimately give rise to an *Æcidium* fungus on certain members of the *Boraginaceæ* [*e.g. Symphytum asperrimum* (prickly comfrey), *Symphytum officinale* (common comfrey), etc.], which also produces spores. The *Æcidium* spores (according to the late Dr. De Bary[1] and other authorities) reproduce (on certain cereals and grasses) the *Uredo*, or the "rust" stage, of *P. rubigo-vera.*

This fungus infests wheat, barley, rye, as well as certain grasses.

Prevention.—(1) A good system of land drainage lessens the attacks of this fungus. (2) According to Mr. W. G. Smith, F.L.S., "It is now generally accepted as a fact amongst practical men, that after dressing the land with farmyard manure and nitrate of soda mildew often puts in a strong appearance; but after *mineral manures*, bone superphosphate, and bone meal drilled with the seed, rust and mildew are much less apparent. There can be no doubt that farmyard manure has a tendency to produce a gross soft growth in corn which is suitable for fungi, and that mineral manures, on the contrary, have a tendency to produce a firm, stiff growth unsuited for rust and mildew." (3) Seeds from infested plants should not be drilled. (4) It would be well for farmers to burn mildewed straws, as this material (when used as litter) is a suitable medium for the teleutospores to hibernate in. The author has experimentally shown that certain fungal spores are capable of hibernating for months, in farmyard manure, without losing their vitality (*Chemical News*, vol. 49, p. 279).

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[1] *Neue Untersuchungen über Uredineen*, ii. (1866).

Cure.—(1) Lands which have grown infested crops should be treated with quicklime or gas-lime. (2) A top-dressing of iron sulphate (½ to 1 cwt. per acre) in the spring destroys the early stage of *P. rubigo-vera.*

The Summer Rust of Corn (*Puccinia graminis*, Fig. 45). The *Uredo*, or early stage, of this fungus makes its appearance in the summer, usually about July. Unlike the "spring rust," the "summer rust" produces pallid spots (sori) on the leaves and culms of corn and grass plants. The early or rust stage is known as *Uredo linearis* (the specific name referring to the elongated form of the sori); and the second or mildew stage as *Puccinia graminis.* The sori of the mildew stage are black, and make their appearance in the autumn and winter. The sori of the rust stage of this fungus are not unlike those of *Puccinia coronata* (see Fig. 37 A and B). If a transverse section of a small rust sorus is examined under the microscope, a mass of oval-shaped spores will be observed, supported on hyphæ rising from a closely-packed mycelium which infests the host-plant (Fig. 45 A). These spores (uredospores) rupture the epidermis of the host-plant, and thereby greatly interfere with its life-history. In fact, the fungus causes disease, by obtaining nourishment from the protoplasm and sap of the living cells of the infested plant, as well as causing no inconsiderable amount of damage by rupturing the epidermis. After liberation, the uredospores may fall on the leaves of wheat and other cereals, where they germinate by giving rise to hyphæ which pass into the interior of the host-plant through the stomata. The hyphæ reproduce the uredo-mycelium with its accompanying spores. During the early autumn the uredo-mycelium produces blackish spores, and when these spores are massed together they give rise to the well-known sori of the corn mildew. The wheat stem and leaves become covered (more or less) with black disease spots belonging to the *Puccinia*, mildew, or perfect state of this fungoid growth. If a transverse section (Fig. 45 B) of one of the disease spots (sori) is examined microscopically, a mass of two-celled spores (teleutospores) will be observed. The teleutospores, like the uredospores, are supported on erect hyphæ rising from a compact mycelium embedded in the tissues of the

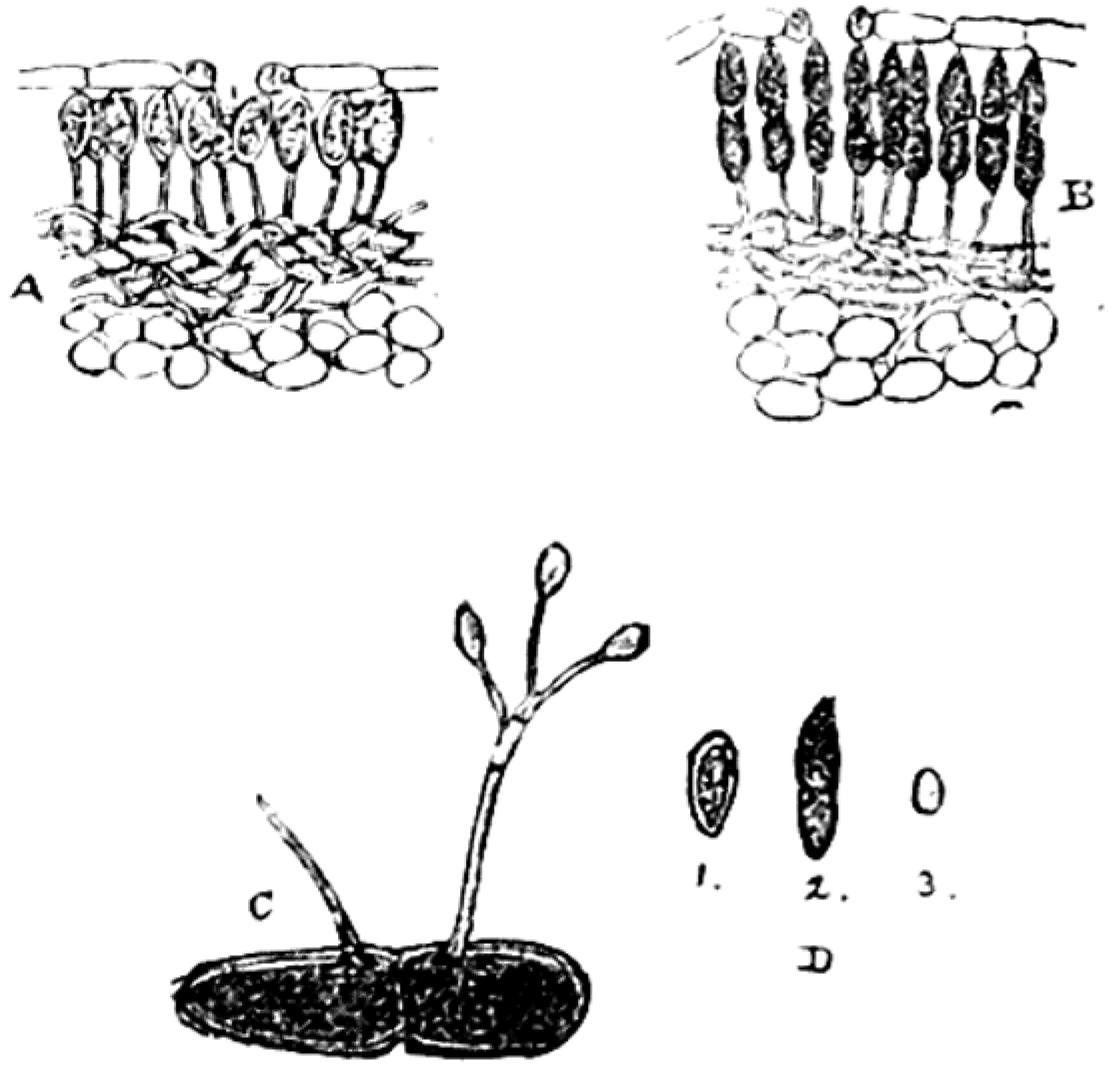

Fig. 45.—The Summer Wheat Mildew (*Puccinia graminis*).

A. A section of a portion of a sorus of *Uredo linearis* (the early stage of *P. graminis*) × 195.
B. A section of a portion of a sorus of *Puccinia graminis* (later stage) × 195.
C. Germinating teleutospore. × 490.
D. Uredospore (1), Teleutospore (2), Pro-mycelium spore (3). × 490.

host-plant. The teleutospores (the "resting-spores" of Plowright) hibernate until the following spring. They then germinate (Fig. 45 C), and subsequently give rise to a short pro-mycelium bearing transparent oval-shaped spores of a yellow colour. According to De Bary (*Monatsbericht der Königlichen Preuss. Akademie der Wissenschaften zu Berlin*, 1865), Plowright (*British Uredineæ and Ustilagineæ*), Carruthers, Sachs, and other botanists, the pro-mycelium spores of this fungus germinate on the leaves of *Berberis vulgaris* (the common barberry bush) giving rise to the fungus known as *Æcidium berberidis*, whose spores are said to reproduce the uredo-mycelium, or the first stage in the life-history of *Puccinia graminis*. On the other hand, Cooke, Berkeley, Smith, and others state that there is no genetic connection between *Puccinia graminis* and *Æcidium berberidis*, and that these fungi are quite distinct. If the latter idea is correct, the pro-mycelium spores must germinate (without producing an *Æcidium*) on various members of the *Gramineæ*, reproducing the uredo-mycelium and its spores.

According to De Bary's school of fungologists, the "summer corn mildew" completes its life-history by alternately living upon two separate plants; it is, therefore, a dimorphic, heterœcious, or metœcious fungus. Mr. Plowright (see his book, *loc. cit.*) states that forty-seven heterœcious species of the *Uredineæ* are now known, and the life-history of eleven of these was first worked out by himself.

It is well known that parasitic mildews cause putrefactive changes to occur within the tissues, etc., of infested plants. The author detected the presence of small quantities of alcohol and lactic acid in the sap of infested or mildewed wheat plants (*Chemical News*, vol. 53, p. 255). These compounds may be produced from the decomposition of glucose which is always present (more or less) in the sap of healthy plants.

Prevention.—(1) As the "mildew of corn" requires moisture for its growth, corn-growing lands should be well drained. (2) Farmyard manure containing infested straw should not be applied to land required for cereals; as the straw (which formed the litter) contains the teleutospores of *Puccinia graminis*. In fact, it would be well to destroy mildewed straw. (3) Mr. W. Carruthers, F.R.S. (*Journ. Roy. Agric. Soc.* [2nd series], vol. xviii., p. 495), states that "the farmer should not permit the barberry to have a place in his hedges or in plantations on his farm." (4) Seed from mildewed corn crops should not be drilled—as Mr. Smith has shown that the disease is hereditary. "It exists in a finely-attenuated state in seeds taken from diseased plants, and can be transmitted in a long interminable line from generation to generation." (5) Clearing hedges of "rusted and mildewed grasses" is an important preventive against the attacks of this farm pest.

Cure.—(1) The author has shown (*Chemical News*, vol. 53, p. 255; and *Journ. Chem. Soc.*, 1886, p. 119) that iron sulphate destroys the wheat mildew and its spores in both stages of their life-history. The author's investigations have been completely and entirely confirmed by Mr. G. W. Edgson (*Journ. Chem. Soc.*, 1886, p. 114), M. Delacharlonny (*Biedermann's Centralblatt für Agric. Chemie*, vol. xviii.), Professor Quantin (*Journ. de l'Agric.*, 1888), M. Gaillot,[1] and others. Therefore, it is advisable for farmers to top-dress wheat crops with iron sulphate in the proportion of ½ to 1 cwt. (per acre) mixed with 5 times its weight of dry earth. (2) As it is possible that "living spores or mycelium may sometimes be present outside the seeds," it would be well for farmers to steep seed wheat in a 2 per cent. solution of iron sulphate for three or four hours. This reagent destroys the spores, etc. M. Chavée-Leroy says: "The recent experiments in France prove conclusively that the use of iron sulphate preserves cereals from mildew."

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CHAPTER V.

THE DISEASES OF MISCELLANEOUS CROPS.

(1) THE PARASITES OF ASPARAGUS (*Asparagus officinalis*).

The Asparagus Beetle (*Crioceris asparagi*) is about a quarter of an inch in length, with a body of a blue-black colour. The yellowish elytra are adorned with a central black cross and black spots. The dark-coloured, oval eggs are deposited by the female beetle on the flower-buds of asparagus plants. The larvæ are "short, fleshy, and dingy grubs; with six short legs and a double series of fleshy tubercles along the lower surface of the abdominal segments, which also serve as legs." These grubs, having previously eaten the leaves and soft shoots of the host-plants, retreat to the earth, where they spin a cocoon in which they change to the pupal stage. In about sixteen days the pupæ are transformed into perfect insects. There are several broods of this insect during the season (June to September).

M. Lucas (*Annales de la Société Entomologique de France*, 1888) recently discovered two natural enemies of *Crioceris asparagi*. One is the *Calocoris chenopodii* (belonging to the *Heteroptera*), which sucks the juices from the larvæ of the asparagus beetle; while the other is an internal parasite (*Myobia pumila*). The pupæ of this Tachinid fly is transformed into the perfect insect within the skins of the *Crioceris* larvæ.

Prevention.—(1) Sprinkling the plants with soot causes both larvæ and beetles to make a retreat from the asparagus beds. (2) Syringing the infested plants with warm water has also been recommended for the same purpose. (3) Dressing asparagus beds in the spring with salt and quicklime greatly lessens the attacks of this pest.

Cure.—(1) In the United States "Paris green" (the poisonous copper arseniate) has been effectually used as a remedy against the attacks of *C. asparagi.* The "Paris green" is suspended in water ($\frac{1}{2}$ lb. to 40 gallons), and the asparagus beds are watered with 40 gallons of the mixture per acre (Riley's *Insect Life*, vol. i. p. 110, and *The Fourth Report of Entomological Commission, U.S.A.*, p. 143). (2) The author has found that a small quantity of crude or commercial naphthalene placed along the rows, followed by syringing the infested plants with cold water, completely destroys both the larvæ and beetles.

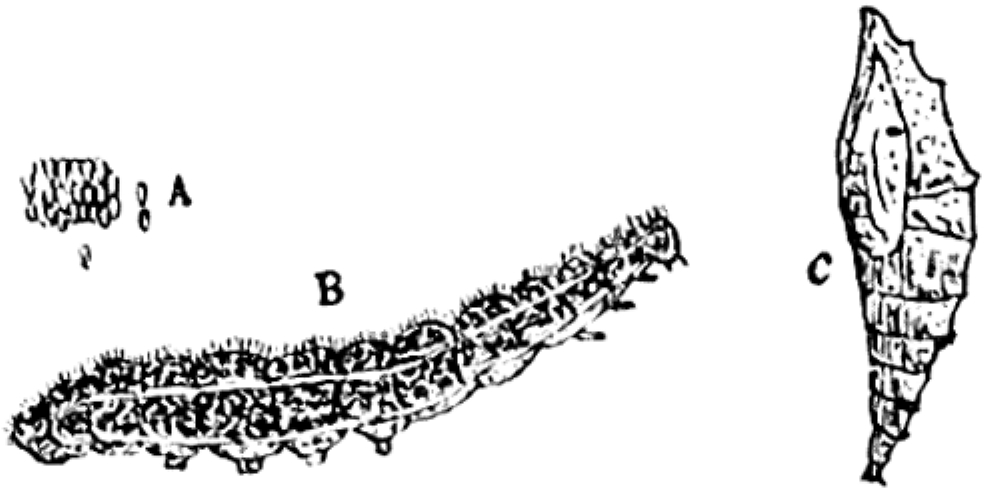

Fig. 46.

(2) THE PARASITES OF CABBAGE (*Brassica oleracea*) AND ALLIED CROPS.

(*a*) **The Large White Butterfly** (*Pontia brassicæ, Pieris brassicæ*). These butterflies "hover over the beds of *cabbages* and lay their eggs on the leaves. The eggs are small yellowish bodies (Fig. 46 A) somewhat resembling the fluted sugar-loaves of the grocers' windows. After the eggs have remained on the leaves for a few days, the little caterpillars break out of them and proceed to their work of destruction upon the tender leaves of the cabbage. They eat voraciously, soon piercing the parenchyma of the leaves with a thousand holes, and often completely destroying nearly the whole crop of oleraceous plants (cabbages, broccoli, cauliflowers); and rendering the plants disgusting by the quantity of their excrements" (Dallas). The hairy caterpillars are more or less green or yellow, with black spots (Fig. 46 B). They are provided with mouths well adapted for masticating or chewing hard substances, hence the damage done to cabbages and similar plants. The caterpillars change their skins three times, when they retire to some quiet spot and there turn to green-coloured pupæ (Fig. 46 C). "The butterfly comes out in about a fortnight from the midsummer brood of chrysalids (pupæ), but not till the following spring from the chrysalids that form in the autumn." The perfect insect or butterfly has four white wings. The mouth is purely suctorial, and is provided with a spiral trunk fitted for drinking up the juices of flowers. Fortunately for farmers and market gardeners, there are two natural foes of *P. brassicæ* belonging to the *Ichneumonidæ*. Both *Microgaster glomeratus* and *Pteromalus brassicæ* lay their eggs in the larvæ and pupæ respectively of *P. brassicæ*. The eggs of the former parasitic fly turn to small larvæ which feed "on the fat of their host, who, bad luck to him, goes on eating faster than ever. Retribution, however, must come in time, and when the cabbage-eater should turn into a chrysalis, the parasitic guests are thinking of changing too, so they burst through the skin of their host, and leave him to perish." *Pteromalus bras-*

sicæ lays its eggs within the pupæ of *Pontia brassicæ.* After the hatching of the eggs the parasitic larvæ feed on the contents of the pupæ.

Prevention.—(1) Brushing infested plants so as to displace the caterpillars, is a means of preventing further injury. Before brushing, a small quantity of crude naphthalene should be placed round each plant. This prevents the caterpillars from returning up the stems. (2) Dredgings of sulphur and salt over infested plants have been recommended for keeping off the attacks of this pest. (3) Good cultivation and a liberal dressing of the most suitable manures "has been found serviceable; and the application of liquid manure will save a crop even when badly infested."

Cure.—(1) Probably hand-picking is the most effectual remedy. "Children should be encouraged to catch the butterflies (as well as the caterpillars) and crush them, and not be blamed for killing the 'poor little pretty butterflies.' 'Handsome is that handsome does,' and the converse to this is, in the same sense, equally true, 'Ugly is that ugly does.'" (2) Syringing the plants with weak solutions of salt, soap-suds, or lime is said to destroy these caterpillars. (3) Watering the crops with a solution of iron sulphate (2 per cent.) destroys the larvæ of *Pontia brassicæ*, and is beneficial (as a plant-food) for cabbage plants. (4) In the United States kerosene emulsion has been used for destroying the larvæ of the cabbage butterfly (Riley's *Insect Life*, vol. i. p. 27).

The Small White Butterfly (*Pontia rapæ, Pieris rapæ*) and **The Green-veined White Butterfly** (*Pontia napi, Pieris napi*). The eggs of both these butterflies are laid singly on the underside of the leaves of cabbage plants. The larvæ of these butterflies are both

Library

of a green colour. Those of *Pontia rapæ* have rows of yellow spots along each side, while those of *Pontia napi* are of a reddish hue. The pupæ of *P. rapæ* are a fleshy-brown colour, spotted with black, while those of *P. napi* are pale green or yellow with brown tips. The perfect insects measure about two inches across the wings. The anterior wings of the "Small White" are white with blackish tips, and two black spots on each wing. The posterior wings are white above and yellow below. The anterior pair of the "Green-veined" are white with greyish tips and veins. There are also two black spots nearly in the centre of each wing. The under surface of the anterior wings is yellow with darker veins and spots. The posterior wings are white above and lemon-yellow below with greenish-coloured veins. *P. brassicæ*, *P. rapæ*, and *P. napi* all feed upon turnips as well as cabbages.

Prevention and Cure.—See those already recommended for *Pontia brassicæ*.

The Turnip Moths, already described, also attack cabbage plants.

The Cabbage Moth (*Mamestra brassicæ*) vies with the cabbage butterflies in the injury which it does to oleraceous plants. The moths are of a brown colour, and the anterior wings are marked with black streaks. The posterior wings are brown with a greyish base. The eggs are laid on the leaves, where they are hatched in four or five days. The larvæ (which feed upon the host-plants) are green, with dusky stripes on the back, and dingy yellow ones on each side. When fully grown, the larvæ are about an inch and a quarter in length. They turn to the pupal stage in the earth, where they hibernate until the following summer.

Prevention.—Previously infested lands should be treated with gas-lime. This destroys the brown pupæ and prevents any mischief being done during the following season.

Cure.—(1) Hand-picking (by children) is one of the mos teffectual remedies. (2) Poultry eat the pupæ, and are therefore of service in clearing the ground of this pest. (3) Soot, salt, and sulphur are useful top-dressings.

The Great Yellow Underwing Moth (*Noctua pronuba*) belongs to the *Noctuidæ*, a group of the *Lepidoptera*, which are chiefly nocturnal in their habits. The moths make their appearance in June; and are known by the dark-brown anterior and yellow posterior wings. The eggs are laid on certain plants in July. The larvæ, known as surface caterpillars, are nocturnal—feeding during the night and hiding under clods, etc., during the day. When mature, the larvæ measure about one and three-quarter inches long, and the colour of the integument varies from sage-green to brown. There is a dark-brown band along the back, while the under side is of a pale-green colour. The *larvæ* feed during the autumn, and hibernate beneath clods of earth, etc. In the spring (after feeding for a short time) these larvæ construct earthen cells, in which they turn to red pupæ. The pupæ are transformed into moths in June or July.

Prevention.—(1) Burn such weeds as bittersweet and docks, as the caterpillars of *N. pronuba* feed on these plants as well as on the varieties of cabbage.

(2) The rook, jackdaw, chiff-chaff, blue-tit, and other insectivorous birds destroy these farm pests.

Cure.—Gas-lime, tobacco-water, soft-soap, lime, soot, quassia, quicklime, and sulphur have been prescribed as remedies.

The Boll Worm (*Heliothis armigera*), which is the larva of one of the *Noctuidæ*, causes considerable damage to the cotton, corn, leguminous, oleraceous, and other crops of the United States. It is only found to a very limited extent in the south of England. For further information see Dr. Riley's *Fourth Report of Entomological Commission, U.S.A.*, pp. 355–381, and *Insect Life*, vol. i. p. 331.

The Cabbage Plant-Louse (*Aphis brassicæ*) is one of the so-called "green flies," and has a somewhat similar life-history to those already described. These aphides "do much harm by inserting their suckers in the plants and drawing away the juices; and also causing a much deformed and diseased growth."

Prevention.—A good system of cultivation, and a liberal use of the most suitable manures, is a means of lessening the destructive powers of this insect.

Cure.—(1) Top-dressings of lime, soot, and sulphur are recommended as remedies. (2) Drenching the infested plants with a solution, containing one part of ammoniacal or gas-liquor and twelve of water, completely destroys the cabbage aphis. (3) Solutions containing tobacco, soft-soap, and quassia, are said to have a like effect. (4) Manuring the land with a top-dressing of iron sulphate (½ cwt. per acre) has a tendency to produce a luxuriant growth, and after this treatment the plants are rarely attacked by this injurious insect.

The Crane Fly (*Tipula oleracea*). The grubs, called leather-jackets, of this insect attack the roots, etc., of the varieties of cabbages, as well as those of gramineous and other plants.

Prevention and Cure.—See chapter iv.

The Cabbage Gall Weevil (*Ceutorhynchus sulcicollis*) has already been described under "The Parasites of Turnips."

The Cabbage Fly (*Anthomyia brassicæ*) and **The Cabbage Root-eating Fly** (*Anthomyia radicum*) belong to the same genus as, and are somewhat similar to, the beet or mangel fly already described. The grubs of the first-named insect injure the cabbage plants, "by eating passages in the stem and roots, and sometimes destroying whole fields of cabbages by subsequent disease, or decay in wet weather, of the roots and lower part of the stalk." The whitish grubs are devoid of legs, and measure about one-third of an inch in length. The grubs turn to pupæ in the earth; the latter are then transformed into perfect insects in about twenty days, unless the pupæ are formed late in the season, in which case they hibernate until the following spring. There are several generations during the summer and autumn. The grubs of *A. radicum* are of a yellowish colour, and feed in the roots of the cabbage and other oleraceous plants. The perfect insect has a slender, pointed abdomen. In this point it differs from *A. brassicæ*, which has a more or less rounded abdomen.

Prevention.—(1) Rotation of crops. Farmers and market gardeners should not grow cabbages on the same plots of land season after season. (2) Dressing the land with superphosphate of lime has been recommended as a means of prevention.

Cure.—(1) Lime-water is stated to destroy the maggots of these two dipterous flies. (2) Lands previously infested with these insects should be treated with gas-lime or quick-lime.

Clubbing in Cabbages (*Plasmodiophora brassicæ*) has already been described in chap. iii. Some agriculturists and entomologists still believe that clubbing in cabbages and other brassicaceous plants is due to the attacks of insects (!). This is a mistake, for true clubbing is undoubtedly due to a fungus belonging to the *Myxomycetes*. On the other hand, certain wart-like excrescences are produced on the roots of turnips and cabbages by a small weevil (*Ceutorhynchus sulcicollis*); but these outgrowths are quite distinct from the true club-root.

Prevention and Cure.—See under the heading of "The Parasites of Turnips."

The Mould of Cabbages (*Peronospora parasitica*) belongs to the same genus as the potato-disease fungus, and has a somewhat similar life-history. The mycelium, which is provided with haustoria (suckers), infests the interior of the leaves of cabbages, and produces conidiophores (bearing conidia), which pass through the stomata on the under surface of the leaves. The pathological action of this fungus is to produce putrefactive changes in every part of the leaf which comes in contact with the mycelium. The conidiophores (unlike those of *Peronospora infestans*) have a tendency to twist, and therein agree with another fungus, *P. ganglioniformis*, described later in this chapter. The conidia of the "cabbage mould" germinate on various cruciferous plants; and, like *P. infestans*, this cabbage fungus produces oöspores (resting-spores) of a yellow-brown colour, which hibernate for several months. *P. parasitica* is common in the summer and autumn.

Prevention.—(1) Destroy all the stumps of previously infested crops. (2) The farmer or market gardener should, as far as possible, destroy shepherd's purse, whitlow grass, pennycress, coral root, hairy bittercress, and many other weeds, for both the oöspores and the mycelium of this fungus are to be found on these plants, as well as on cabbages and turnips.

Cure.—See those already described for destroying *P. infestans* (the potato-disease fungus).

The Fusisporium of Cabbages (*Fusisporium aurantiacum*) has a similar life-history to *F. solani* already described. It infests the leaves and stems of the host-plant.

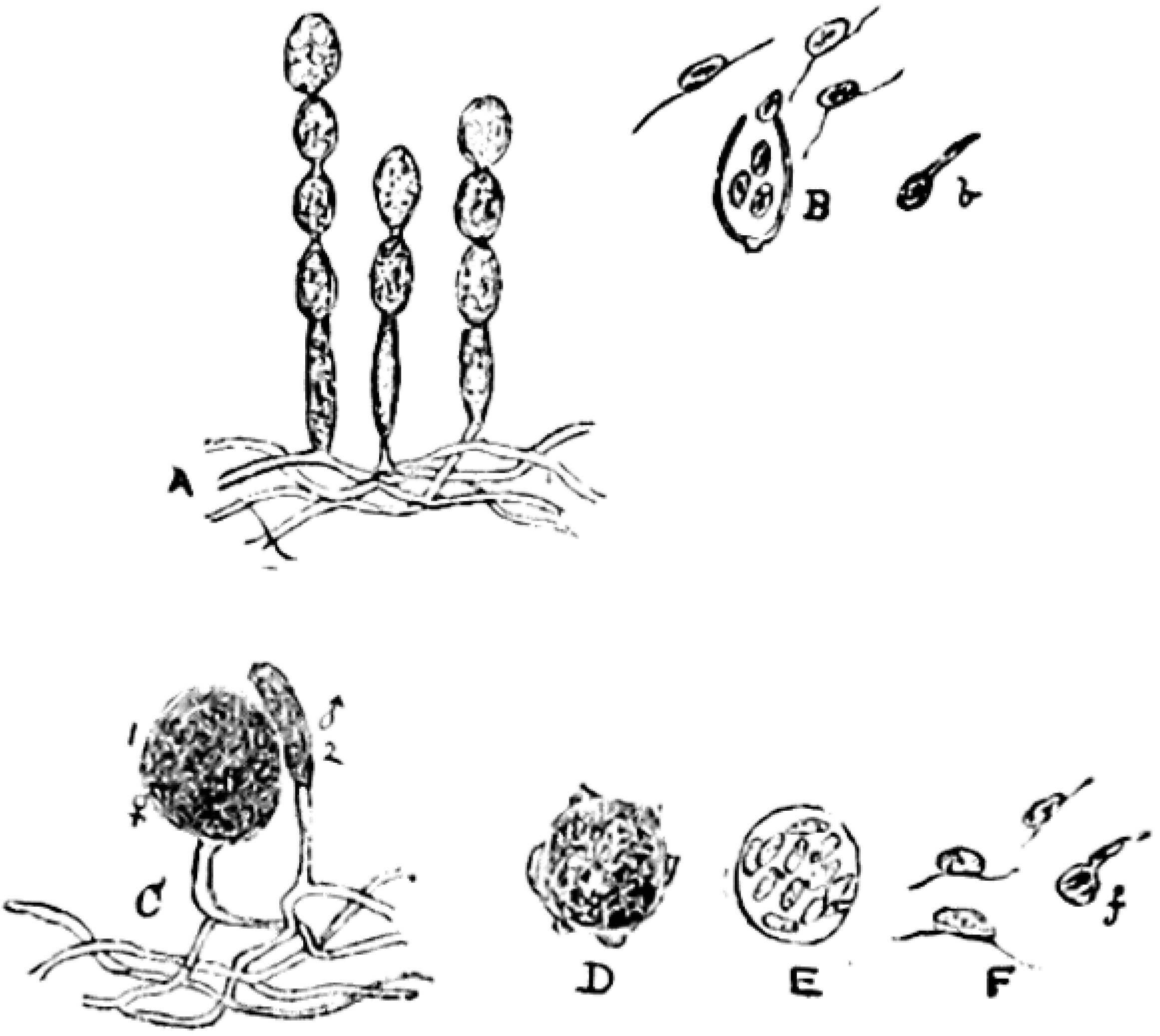

Fig. 47.—White Rust Fungus of Cabbages (*Cystopus candidus*).

A. Mycelium bearing conidia. × 195.
B. Conidium (zoösporangium) producing zoöspores. × 405.
C. Oögonium (1) and antheridium (2). × 195.
D. Oöspore (resting-spores). × 195.
E. Inner membrane of oöspore containing zoöspores. × 195.
F. Zoöspores. × 405.
b and *f*, Zoöspores germinating.
(*Magnifications according to Zeiss.*)

The White Rust of Cabbages (*Cystopus candidus*, Fig. 47) causes no inconsiderable amount of damage, in certain seasons, to cabbages, cauliflowers, and allied crops. This disease is known by the swollen leaves, stems, etc.

(of infested plants), which become marked with elongated white spots. The mycelium of *C. candidus* lives amongst the intercellular spaces of the host-plant; and, like that of *Peronospora parasitica*, is provided with haustoria (suckers). When a white spot or sorus of *Cystopus* is examined under the microscope, chains of oval-shaped conidia are seen rising from an embedded mycelium (Fig. 47 A). The granular protoplasm of each conidium gives rise, on a damp surface, to a number of secondary spores (zoöspores) provided with cilia (Fig. 47 B). After a time the cilia disappear. The zoöspores germinate and reproduce the mycelium and its accompanying conidia and secondary spores. By the continual reproduction of the mycelium and zoöspores, the disease is propagated from leaf to leaf and from plant to plant. The mycelium of *Cystopus* also gives rise to antheridia and oögonia (Fig. 47 C), or male and female organs respectively. After fertilization, each oögonium produces oöspores, *i.e.*, resting-spores (Fig. 47 D). Before the oöspores are ripe several months must elapse, and the ripening process goes on within the tissues of the host-plant. In fact, the fertile oöspores hibernate until the following spring, when they "germinate on the ground during wet weather." The protoplasm of the oöspores gives rise to zoöspores (Fig. 47 E and F), which ultimately reproduce the "white rust" mycelium, and its accompanying conidia on the young leaves, etc., of cabbages and allied plants. "No doubt the little motile zoöspores are carried through moist air by currents of wind, and distributed in every direction throughout the country."

Prevention.—(1) Destroy, as far as possible, cruciferous weeds, especially shepherd's purse. (2) Destroy all infested stumps, etc. (3) Rotation of crops tends to lessen the ravages of *Cystopus* and other parasitic fungi. (4) Top-dress the land (when the plants are young) with half cwt. of iron sulphate mixed with 5 to 10 times its weight of sand or dry earth per acre. This dressing prevents the attacks of "white rust," and is most beneficial as a plant-food.

Cure.—Water the infested plants with a solution of iron sulphate (1 to 5 per cent. solution) at the rate of 2 or 3 gallons per acre.

(3) THE PARASITES OF CELERY (*Apium graveolens*).

The Celery Stem Fly (*Piophila apii*). The larvæ of this dipterous fly feed within the stems and leaf-stalks of celery plants. The cream-coloured larvæ are devoid of legs, and turn to pupæ within the host-plants. The thorax and abdomen of this fly are black, while the head is of a brown colour. *P. apii* is about half an inch across the extended wings, which are almost colourless. The fly makes its appearance in May, and there are two broods during the year.

Prevention.—(1) Destroy infested stems. (2) Top-dress the young plants with soot or a mixture of slaked lime and soot.

The Celery Leaf Miner (*Tephritis onopordinis*) has already been described as a "parasite of parsnips."

The Red Rust of Celery (*Puccinia apii*). The early stage of this fungus is known as *Uredo apii*, or "red rust"; and the later stage as *Puccinia apii*, or the "black mildew" of celery. The fungus is allied to, and has a somewhat similar life-history to, *Puccinia graminis* already described.

Prevention.—(1) As Dr. M. C. Cooke proved the disease to be hereditary, seeds from infested plants should not be sown. (2) As far as possible, all umbelliferous weeds should be destroyed.

Cure.—See those under the heading of *Puccinia graminis.*

The Celery Mildew (*Puccinia heraclei*), like the preceding fungus, belongs to the *Uredineæ.* It sometimes infests celery plants.

Prevention.—(1) Destroy all umbelliferous weeds, especially cow-parsnip (*Heracleum sphondylium*), and wild chervil (*Anthriscus cerefolium*). (2) Sow perfectly sound seeds.

(4) THE PARASITES OF CUCUMBERS (*Cucumis sativa*).

The Cucumber Eelworms (*Tylenchus cucumeris?*) belong to the *Anguillulidæ*, or "thread-worms." They are said to destroy the roots and rootlets of cucumber plants.

The Cucumber Thrips (*Thrips cucumeris?*) often causes considerable damage to cucumber plants. It belongs to the same genus as *Thrips cerealium* already described.

The Cucumber Root Fungus (*Ustilago cucumeris*, Fig. 48) was discovered by the author infesting the roots and rootlets of *Cucumis sativa.*[1] During the summer of 1887, Mr. E. F. Crocker (a market gardener, of Ham Green, Bristol) sent the author a large number of the roots of cucumber plants, with "peculiar knot-like bodies" upon their external surfaces (Fig. 49); and from a quantitative estimation of the nitrogen contained in these "swellings," and in the roots proper, the author was at first inclined to believe in the hypothesis of Dr.

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[1] *Proceedings Royal Society of Edinburgh*, vol. xv. p. 403.

Tschirch, applying to the outgrowths on the roots of *Cucumis.* Tschirch (*Berichte der Deutschen Botanischen Gesellschaft*, Heft 2, 1887), in describing the root-tubercles found in the *Leguminosæ*, stated that most probably they were storehouses for nitrogenous compounds—these compounds being subsequently used up in the ripening of the seed. On submitting the nodules, roots, etc., of *Cucumis* to chemical analysis, the following percentages of albuminoïds were obtained :—

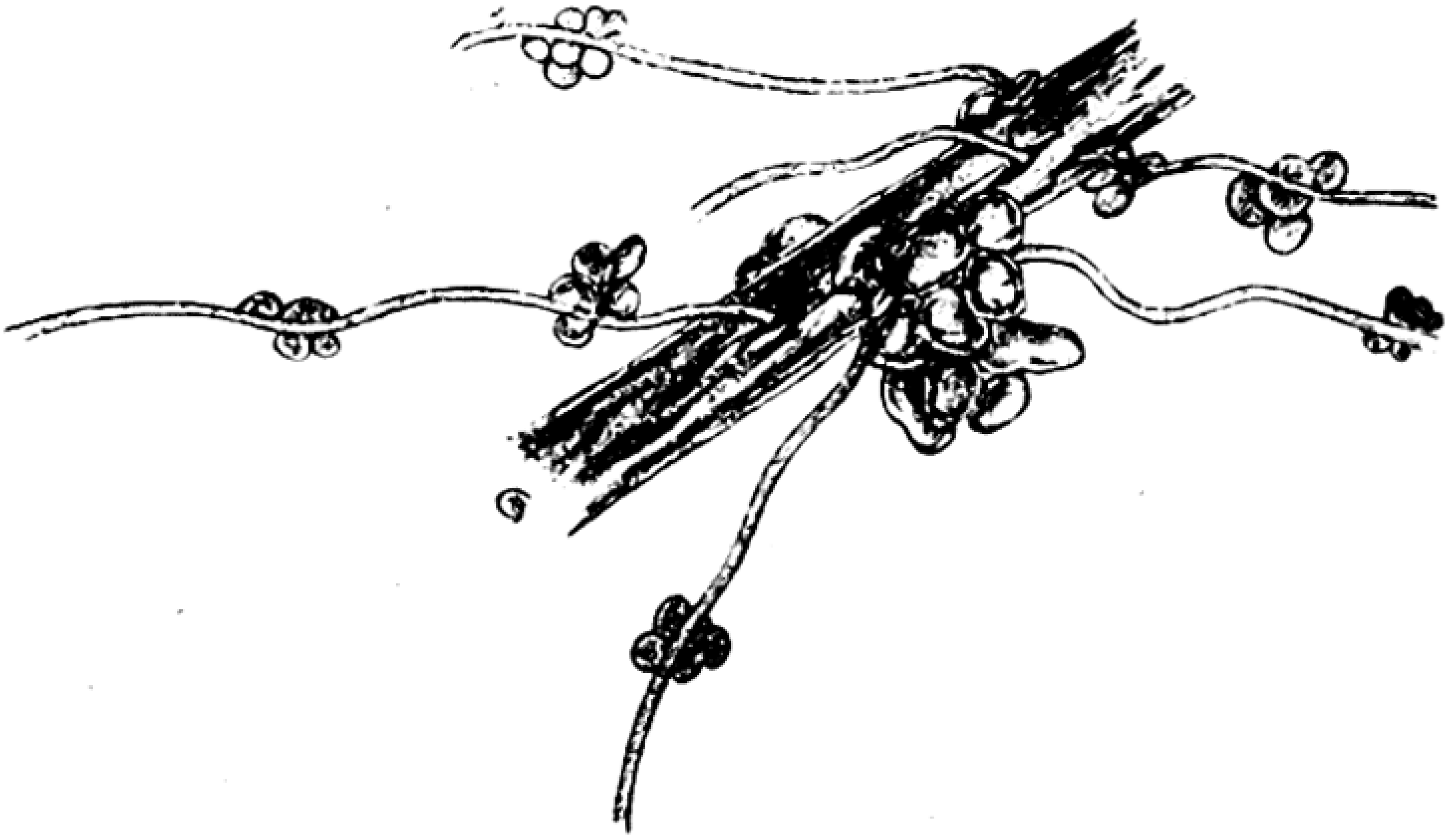

Fig. 48.—Root of Cucumber

Infested with one of the Ustilagineæ, causing nodular out-growths. (Nat. size.)

	I.	II.	III.
Albuminoïds (nitrogenous substances) in nodules	20·24	19·96	20·51
,, in roots (without nodules) . . .	1·92	2·00	2·06
,, in stems and leaves	3·21	3·24	3·30

Although the analyses appeared to support Tschirch's idea, it was soon discovered by a microscopical study of the roots, that the nodular outgrowths were due to a parasitic fungus belonging to the *Ustilagineæ*, or the same group of which the "smuts" are important members. Fig. 49 represents a transverse section of a root with nodule. In very thin sections under high power, the nodules are seen to be filled with hyphæ and spores. The spores of this fungus are more or less v-shaped, and are formed by division of the protoplasmic contents of the hyphal filaments which ramify in the root-tissues of the host-plant. Unlike most of the members of the *Ustilagineæ*, the hyphæ of *Ustilago cucumeris*[1] are not divided by transverse septa. The hyphæ (which are many times thicker than the cell-walls of the adjacent tissues) pass, cell by cell, through the cortex of the rootlet, and sometimes across the intercellular spaces (Fig. 50). Branching of the hyphæ is well marked in the tissues of the nodules, and sometimes they send out lateral branches which end abruptly in the cells. The protoplasm of the nodular cells after a time becomes vacuolated (Fig. 50) and filled with spores. The spores of the cucumber-root fungus are found in the soils (where *Cucumis sativa* has been growing) in the autumn and early winter, having been liber-

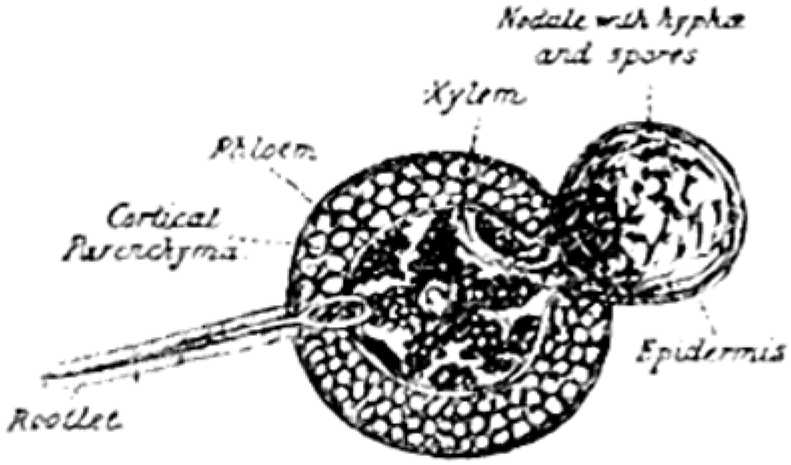

Fig. 49.—TRANSVERSE SECTION OF A ROOT WITH NODULE.
(Under low power.)

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[1] Originally described as *Ustilago cucumis*.

ated by the rotting of the root-nodules. These spores retain their vitality for months,[1] and are then capable of attacking the new seedlings planted in such soils. The spores are easily disseminated by such agencies as air, soils, and streams. *Ustilago cucumeris* produces a diseased condition of the whole plant.

Prevention.—(1) Avoid growing cucumber plants in the same soil season after season. (2) Sow only good healthy seeds.

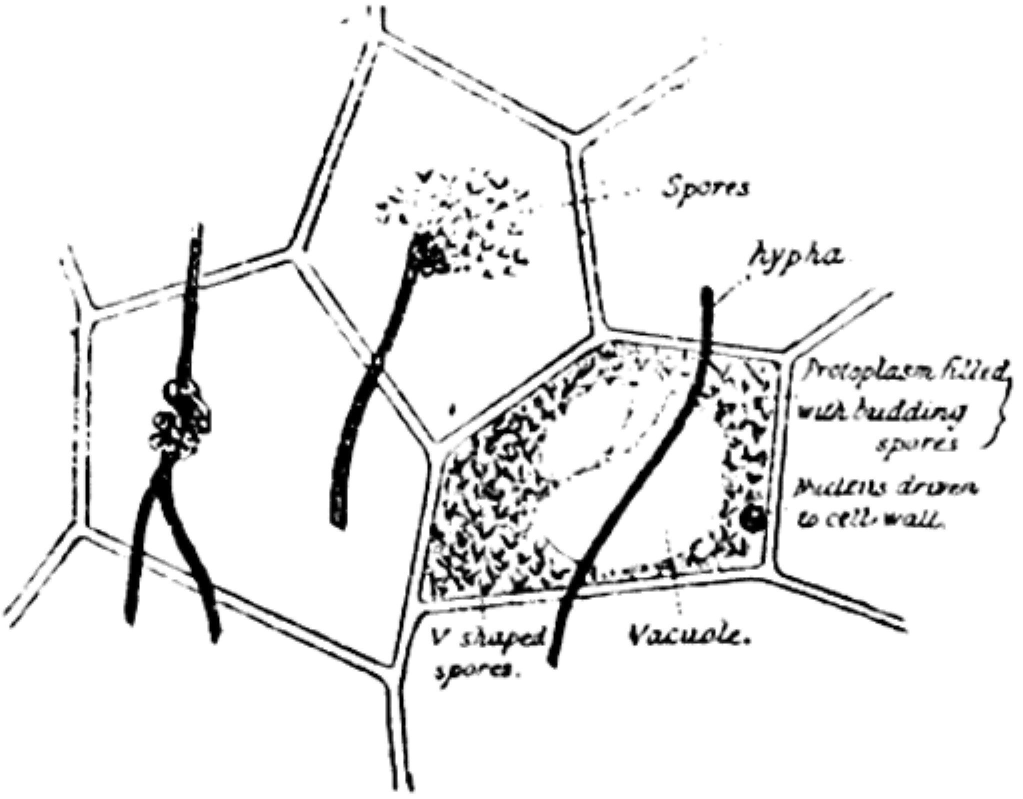
Spores
hypha
Protoplasm filled with budding spores
Nucleus drawn to cell wall.
V shaped spores.
Vacuole.

Fig. 50.—Spore Formation.
× 713.

Cure.—Water the infested plants with a 4 per cent. solution of iron sulphate. The iron sulphate completely destroys the fungus, but does not injure the host-plant.[2] Mr. E. F. Crocker (already mentioned) has been successful in destroying the said fungus by using iron sulphate. He wrote the author as follows:—"I planted the present house of cucumbers in the second week in August (1887), and have used the iron sulphate. I find *no trace of disease*, although the plants were diseased when I first wrote to you in August. I have been able to cut scores of fruits of the most splendid quality, and they have been extraordinarily fruitful. It is the first house of cucumbers I have grown without disease for at least ten years."[1]

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[1] *Proceedings Royal Society, Edinburgh*, vol. xv. p. 410.
[2] *Ibid.*, p. 409.

(5) THE PARASITES OF HOPS (*Humulus lupulus*).

According to Linnæus (*Linnæi Amœnitat. Academ.* vii. p. 452) hops were brought to Europe by the Goths from Asiatic Russia. Whether this be true or not, their proper cultivation in this country only dates from 1524.[2] Hops require a rich, deep soil, and should be grown on freshly broken, well drained, and highly manured land.

The Hop Aphis (*Phorodon humuli*), "green fly," or "hop blight," is too well known among hop-growers to require anything more than a general description. "The genus *Phorodon*, to which it belongs, is distinguished from others of the *Aphidinæ* by the horns (antennæ) being hardly longer than the body, together with the lowest joint being toothed or gibbous, and the tubercles on the forehead each having a strong tooth." Dr. C. V. Riley[3] was the first entomologist who conclusively proved that *P. humuli* hibernates upon damson, plum, sloe, and other trees of the genus *Prunus*. He says in *Insect Life*, vol. i. p. 134: "Hibernating at the present season of the year

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[1] *A Treatise on Manures*, p. 302.

[2] Houghton's *Husbandry and Trade Improved*, vol. ii. p. 457 [A.D. 1727].

[3] *Gardeners' Chronicle*, Oct. 27th, 1887; *Insect Life*, vol. i. pp. 70 and 133.

(winter), the little glossy, black, ovoid eggs of the species are found attached to the terminal twigs, and especially in more or less protected crevices around the buds of different varieties and species of *Prunus*, both wild and cultivated. From this winter-egg there hatches a stem-mother, which is characterized by somewhat stouter and shorter legs and honey tubes than in the individuals of any other generation. Three parthenogenetic[1] generations are produced upon *Prunus*, the third becoming winged. This last is what Lichtenstein called the 'pseudogyna' or migrant; and it instinctively flies to the hop-plant, which is entirely free from the attack during the development of three generations upon Plum. A number of parthenogenetic generations are produced upon the hop-plant until in the autumn, and particularly during the month of September, winged females are again produced. This is the 'pupifera' of Lichtenstein, or return migrant; and she instinctively returns to the plum. Here she at once settles, and in the course of a few days, according as the weather permits, produces some three or more young. These are destined never to become winged, and are true sexual females. Somewhat later, on the hop-plant, the true winged male, and the only male of the whole series, is developed; and these males also congregate upon the plum, on the leaves of which, toward the end of the season, they may be found pairing with the wingless females which stock the twigs with winter-eggs. . . . Each parthenogenetic female is capable of producing on an average one hundred young, at the rate of one to six per day. Each generation begins to breed about the eighth day after birth, so that the issue from a single individual easily runs up, in the course of the summer, to trillions. . . . Therefore a single stem-mother may, under favouring circumstances, blight hundreds of acres in the course of two or three months."

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[1] Parthenogenesis is a term applied to a function of those females who produce fertile eggs without previous impregnation.

Prevention.—(1) Trees belonging to the genus *Prunus* should be thoroughly washed with lime in both the autumn and spring. (2) The natural enemies of the *Aphides* are the larvæ of the *Coccinellidæ* (the "lady-bird" beetles).

Cure.—The most effectual remedy used in this country is a decoction of soft-soap and tobacco (20 lbs. of soft soap to 100 gallons of water, and then ¼ lb. of tobacco added). Mr. Whitehead, F.L.S., says that "the cost of washing varies from thirty to thirty-five shillings per acre each time it is done. Great care must be taken to wash every leaf underneath, and the process generally must be repeated twice or even thrice." "Washing is done by means of a large garden-engine, fitted with a pump, and a long length of gutta-percha hose on each side, having a single jet, or rose, or spray syringe, which can be directed under the leaves and round the bines, thoroughly cleaning the plants" (*Ormerod*). But undoubtedly the best machine for this and similar purposes is the Pneumatic Distributor or Strawsonizer invented by Mr. G. F. Strawson, of Newbury. In this machine both liquid and solid insecticides are distributed by means of a blast of air "produced by a fan actuated by the travelling wheels of the machine, and worked up to a velocity of 3,600 revolutions per minute."

The Hop Flea (*Haltica concinna*) belongs to the same genus as, and is somewhat like, the "turnip fly." The hop flea, or beetle, causes considerable damage, in the spring, by piercing the shoots; and, later in the season, the white larvæ feed on the "cones," etc., of the hop-plant. The eggs are deposited in the cones, bine, or under the cuticle of the leaves; and when laid in the summer they are hatched in about twelve days. The beetles are of a greenish-black hue, "with a brassy tint," and the elytra are dotted. According to Mr. Whitehead, "these flea-beetles hibernate in the perfect state in the ground close to the hop-hills, or in the hollow dead bines left on the stocks, or in the pieces lying on the ground near them."

Prevention.—(1) Top-dress the young shoots with lime or soot. (2) Good cultivation and a generous use of manures. The application of nitrogenous and phosphatic manures has been recommended.

Cure.—(1) In the United States a solution of white arsenic (arsenious oxide), in the proportion of 1 lb. to 200 gallons of water, is used for destroying the hop-flea (Riley's *Insect Life*, vol. i. p. 76). (2) In the same country a dilute solution of Paris green has also been used for the same purpose. "American entomologists wonder that we do not employ arsenic in England as an insecticide. Paris green has been used in America more extensively than any other substance. As a wash, about a pound is put into 100 gallons of water. When used dry, dusted on as a powder, about one pound is put to thirty pounds of flour or gypsum, and about twenty pounds distributed over an acre" (*Whitehead*).

The Hop Frog Fly (*Eupteryx picta*, or "jumpers") belongs to the same genus as the potato frog fly already described. It is a small yellowish-green insect spotted with black. It punctures the leaves, bines, etc., of the hop-plants to extract the juices.

Prevention.—Destroy nettles and other weeds. Clean cultivation is essential for the growth of hops.

Cure.—See the remedies recommended for the "hop aphis" and the "hop flea."

The Hop Bug (*Lygus umbellatarum*) also sucks the juices from various parts of the hop-plant. It belongs to the *Hemiptera* (plant-bugs), and is about a quarter of an inch in length. The elytra are of a reddish colour.

Prevention.—A thorough cleansing of the land after the harvest greatly reduces the attacks of this injurious insect.

Cure.—Syringing and dusting the vines with the insecticides already mentioned destroy *Lygus* as well as other hop-pests.

The Pale Tussock Moth (*Dasychira pudibunda*). The larva of this moth is known as the "hop-dog." It is of a straw-colour, and the incisions between some of the segments are deep black, like velvet. "On the fifth to the eighth segments there are dense yellow tufts on the back. On the twelfth segment a longer dull red tuft appears." The larvæ (each about 1½ inch long) feed on the leaves of hops and of various trees. In the autumn, while on the hop-plant, they spin a slight cocoon, in which they turn to the pupal stage. The pupæ are transformed into moths the following May.

Prevention.—Destroy the cocoons by hand-picking, etc.

Cure.—Syringe the hop-vines with the insecticides already mentioned.

The Ghost Moth (*Hepialus humuli*). The larvæ of this moth infest the roots of hop-plants. They are of a cream colour with brown heads, and measure about two inches in length when fully grown. They turn to pupæ in the ground. According to Mr. Whitehead they are rare.

Prevention.—A thorough cleaning of the land is essential, as the larvæ of *Hepialus* feed on the roots of the common nettle, burdock, and other weeds.

Cure.—In Germany crude naphthalene has been used with marked success. A small quantity of this substance is placed round the stocks of the vines.

The Hop Snout Moth (*Hypena rostralis*) is about an inch across the extended wings, and is known by the snout-like appendage of the head. The larvæ are of a green colour, and feed upon the leaves of the hop-plant. They pass the pupal stage on the leaves.

Prevention and Cure.—See those recommended for the "hop frog fly" and the "hop aphis."

The Hop Wireworm (*Elater lineatus*) is the larva of the "striped click beetle." The beetle is somewhat like *E. obscurus* (Fig. 36 B), but is distinguished from the latter species by having the elytra striped with grey-coloured lines. The larvæ of *E. lineatus* attack the new shoots of the hop-plants.

Prevention and Cure.—See under the head of "Click Beetles" in chapter iv.

The Red Mite (*Tetranychus telarius*)—the so-called "red spider"—differs from the true spiders by having the head, thorax, and abdomen all in one piece. It belongs to the same genus as another "red spider" (*T. bioculatus*) which threatens serious mischief to the plants of the newly-made tea plantations of Assam. *T. telarius* causes considerable damage to hops, particularly in dry seasons. The leaves of the hop-plants "turn brown, become shrivelled, and fall off."

Cure.—Mr. Whitehead recommends "washing the plants with soft soap and water, or even with pure water, as a remedy for these mites. Washing the plants with 'sulphur-water' is also an effectual remedy."

The Hop Mildew (*Podosphæra castagnei*). This fungus attacks the hops of England, France, Germany, Austria, Belgium, Holland, and the United States. It "frequently destroys the crop of hops entirely in some grounds; and this is often accomplished with wonderful celerity. A few mildewed cones may be noticed in a plantation; and before the crop is ripe, or can be picked, the whole may be reduced to mere blackened lumps of rubbish by the work of the fungus." *P. castagnei* belongs to the group *Ascomycetes*,[1] and De Bary (*Vergleichende Morphologie und Biologie der Pilze*) refers it to the division *Erysipheæ*. Therefore it is closely allied to the pea mildew (*Erysiphe Martii*) described in chapter ii., and has a somewhat similar life-history.

Prevention.—(1) Destroy dandelion, groundsel, daisy, and other weeds belonging to the *Compositæ*, as *Podosphæra* lives upon these plants, as well as upon hops. (2) "Hop bines from infested plants should be burnt, in order to destroy the resting-spores upon them." (3) Mr. Whitehead recommends dressing the land with quicklime or soot after an attack of mildew. (4) Avoid planting "sets" from mildewed plantations; but if infection is suspected, the "sets" should be dipped in a solution of iron sulphate (2 per cent. solution).

Cure.—(1) A solution of iron sulphate has been used in France[2] as a remedy for the vine-disease caused by *Oidium Tuckeri* (the vine mildew). As the vine mildew is allied to the hop mildew, a solution of iron sulphate might prove a cheap remedy for this pest. The solution could easily be distributed by the Strawsonizer. (2) Sulphur has long been employed for destroying the hop mildew. From 45 to 65 lbs. of "flowers of sulphur" per acre should be distributed, if possible, in hot and dry weather. The sulphur should be distributed by means of the Strawsonizer. For the distribution of insecticides and fungicides on *ground* crops, as well as hops, vines, etc., there is no better machine than the Strawsonizer or Pneumatic Distributor.

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[1] The spores are in an ascus.

[2] *Bulletin de la Société Agronomique* (Gironde), 1888.

(6) THE PARASITES OF LETTUCES (*Lactuca sativa* and *Lactuca altissima*).

The Lettuce Fly (*Anthomyia lactucæ*) is allied to the onion fly already described. The female lays her eggs amongst the flowers, and when hatched the larvæ feed on the seed.

Prevention.—(1) Burn the refuse from infested crops. (2) Infested seed should be cleared from "the pupæ or little brown fly-cases" of this parasite.

The Lettuce Root Fly (*Aphis lactucæ*), as its name suggests, seeks the juices of lettuce roots. It is of a yellowish-green colour, and measures about one line in length. The attacks of the insect are recognised by "the plants drooping suddenly without any evident cause."

Cure.—(1) "Drenching the ground round the lettuces with strong soap-suds, soap-suds and tobacco-water, and lime-water" is recommended for this purpose. (2) A *dilute* solution of crude carbolic acid has also been recommended for the same purpose.

The Heart and Dart Moth (*Noctua exclamationis*)

The larvæ of this moth (already described) feed on the roots of lettuces.

The Lettuce Mildew (*Peronospora ganglioniformis*, Fig. 51) produces pallid patches on lettuce leaves, and "in bad cases summer lettuces are quickly reduced to putrescent masses." The conidiophores of this fungus are flattened and slightly twisted (Fig. 51 A). Each terminal branch has a cup-like expansion bearing on minute spicules from three to five conidia. The conidia germinate upon the leaves and give rise to mycelia within and upon the host-plant. Like *Peronospora parasitica* and other species of the *Peronosporeæ*, the lettuce mildew produces oospores (Fig. 51 B) which hibernate "in the old rotting

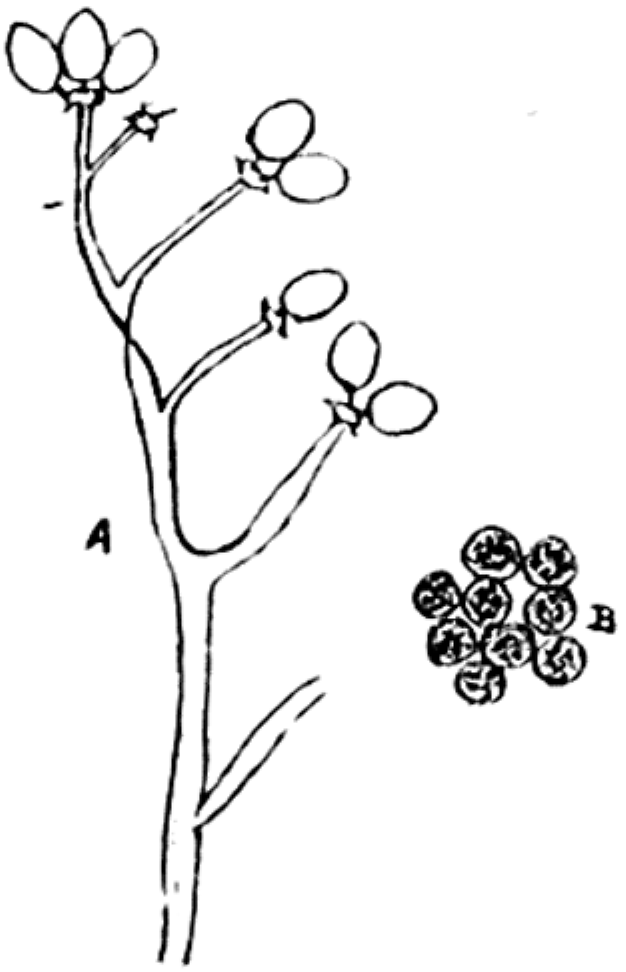

Fig. 51.—Lettuce Mildew (*Peronospora ganglioniformis*).

A. A conidiophore and conidia.
B. Oospores (resting-spores).
× 195 diam. (Zeiss's C. and 3 oc.).

stems of lettuce plants which have been destroyed by the fungus."

Prevention.—(1) Burn infested lettuce stumps, etc. (2) Destroy groundsel, nipplewort, corn sowthistle, and other weeds.

Cure.—Water infested plants with a solution of iron sulphate (2 per cent. solution).

(7) THE PARASITES OF THE TOMATO (*Lycopersicum esculentum*).

The Tomato Eelworm (*Tylenchus sp.?*), like the various "eelworms" already described, belongs to the *Anguillulidæ*. It attacks the roots and rootlets of *L. esculentum.*

The Dodder (*Cuscuta trifolii*), already described as a parasite of clover, attacks tomato plants.

Prevention and Cure.—See chapter ii.

Peronospora infestans also attacks *L. esculentum*, especially when grown out of doors.

Prevention and Cure.—See the treatment of the potato disease in chapter iii.

Chlorosis of Tomato Stems and Leaves. Tomato-growers are well aware that the leaves and stems become spotted or blotched. This is not due to the attacks of fungi or insects, but indicates imperfect nutrition.

Prevention and Cure.—Use dressings containing kainit, nitrate of soda, superphosphate of lime, and iron sulphate.

CHAPTER VI.

CONCLUDING REMARKS.

As we have dealt with many micro-objects in the foregoing chapters, a few details concerning the microscope and its accessories may be interesting and useful to those who may wish to study in a practical manner the various objects mentioned in this book.

The Microscope.—For the investigation of parasitic fungi and farm insects a good microscope is essential; and there are several manufacturers in England and on the Continent who make instruments that are well adapted for such work. The microscopes of Carl Zeiss, of Jena (whose instruments are sold by C. Baker, of 243, Holborn, London), are strongly recommended for students and others who are desirous of purchasing first-class instruments. Zeiss's large microscopes are suitable for the complete investigation of all the organisms mentioned in the foregoing pages. Messrs. Beck, of 68, Cornhill, London, and Messrs. Powell and Lealand, of 170, Euston Road, London, are also manufacturers of good microscopes. A suitable *cheap* microscope is made by Zeiss at about £3. All the higher objectives are available with this instrument (No. vii.), on account of the fine quality of the micrometer movement. Beck's "star" microscope is also a good cheap instrument.

The Objective is the most important part of the microscope, and it is necessary to have good lenses to do satisfactory work. The powers chiefly required for the *entomological* portion of the subjects herein treated are the following:—

Zeiss's Objectives.		*English Objectives.*		
a.	or	3 inches	focal	distance.
aa.	,,	1	,,	,,
B.	,,	$\frac{1}{2}$	,,	,,
C.	,,	$\frac{1}{4}$	,,	,,

These lenses magnify from about 20 to 250 linear diameters with the lowest eye-piece (A, or No. 1). For the examination of *fungi* and diseased vegetable tissues (in addition to the above objectives) Zeiss's E and H, or an English $\frac{1}{8}$ inch and $\frac{1}{12}$ inch, are necessary. To make out the nuclei and cilia of the smallest zoöspores, etc., it is essential to be provided with a still higher power, such as Zeiss's $\frac{1}{12}$ oil-immersion lens, which the author can thoroughly recommend. It has a perfect definition, and everything there is to be seen can be made out with this lens.

The Eye-piece.—Zeiss's Huyghenian eye-pieces Nos. 1, 3, and 5, or the A, C, and D of English makers, are very useful for the economic biologist.

Illumination.—Daylight is the best light to use for the study of parasitic fungi and other transparent objects. But in the winter and for opaque objects (small beetles and other insects) a paraffin lamp is essential. "The one thing requisite in a lamp is that the flame is steady; this depends on the wick fitting properly." For the examination of opaque objects it is necessary to be provided with a stand condenser.[1]

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[1] A description of the stand and sub-stage condensers will be found in manuals devoted to the microscope.

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